Name: ___________________________ Date: _____________

1. A right circular cylinder with a radius of 2.3 cm and a height of 1.4 cm has a total surface area of:
   A) 1.7×10^{-3} m^2
   B) 3.2×10^{-3} m^2
   C) 2.0×10^{-3} m^3
   D) 5.3×10^{-3} m^2
   E) 7.4×10^{-3} m^2

2. A square with an edge of exactly 1 cm has an area of:
   A) 10^{-6} m^2
   B) 10^{-4} m^2
   C) 10^{2} m^2
   D) 10^{4} m^2
   E) 10^{6} m^2

3. Suppose $A = B^nC^m$, where A has dimensions length · time, B has dimensions length^2 · time^{-1}, and C has dimensions length · time^2. Then the exponents n and m have the values:
   A) 2/3; 1/3
   B) 2; 3
   C) 4/5; –1/5
   D) 1/5; 3/5
   E) 1/2; 1/2

4. Which of the following weighs about a pound?
   A) 0.05 kg
   B) 0.5 kg
   C) 5 kg
   D) 50 kg
   E) 500 kg

5. The SI standard of time is based on:
   A) the daily rotation of the earth
   B) the frequency of light emitted by R^{86}
   C) the yearly revolution of the earth about the sun
   D) a precision pendulum clock
   E) none of these

6. The SI standard of length is based on:
   A) the distance from the north pole to the equator along a meridian passing through Paris
   B) wavelength of light emitted by Hg^{198}
   C) wavelength of light emitted by Kr^{86}
   D) a precision meter stick in Paris
   E) the speed of light

7. 1 m is equivalent to 3.281 ft. A cube with an edge of 1.5 ft has a volume of:
   A) 1.2×10^{2} m^3
   B) 9.6×10^{-2} m^3
   C) 10.5 m^3
   D) 9.5×10^{-2} m^3
   E) 0.21 m^3

8. There is no SI base unit for area because:
   A) an area has no thickness; hence no physical standard can be built
   B) we live in a three (not a two) dimensional world
   C) it is impossible to express square feet in terms of meters
   D) area can be expressed in terms of square meters
   E) area is not an important physical quantity

9. Which of the following is closest to a yard in length?
   A) 0.01 m
   B) 0.1 m
   C) 1 m
   D) 100 m
   E) 1000 m

10. A marble has a radius of 2 mm. The order of magnitude of the number of these marbles that can be placed in a jar with a radius of 3 cm and a height of 10 cm is:
   A) 10
   B) 10^2
   C) 10^4
   D) 10^6
   E) 19^8

11. $5.0 \times 10^4 \times 3.0 \times 10^6 =$
    A) 1.5×10^9
    B) 1.5×10^{10}
    C) 1.5×10^{11}
    D) 1.5×10^{12}
    E) 1.5×10^{13}

12. The number of significant figures in 15.0 is:
    A) 1
    B) 2
    C) 3
    D) 4
    E) 5

13. $1.513 + 27.3 =$
    A) 29
    B) 28.8
    C) 28.9
    D) 28.81
    E) 28.813

14. The order of magnitude of the number 0.0649 is:
    A) –2
    B) 6×10^{-2}
    C) 10^{-2}
    D) 10^{-1}
    E) 0.06

15. $5.0 \times 10^5 + 3.0 \times 10^6 =$
    A) 8.0×10^5
    B) 8.0×10^6
    C) 5.3×10^5
    D) 3.5×10^5
    E) 3.5×10^6

16. A cubic box with an edge of exactly 1 cm has a volume of:
    A) 10^{-9} m^3
    B) 10^{-6} m^3
    C) 10^{-3} m^3
    D) 10^3 m^3
    E) 10^6 m^3

17. A right circular cylinder with a radius of 2.3 cm and a height of 1.4 m has a volume of:
    A) 0.20 m^3
    B) 0.14 m^3
    C) 9.3×10^{-3} m^3
    D) 2.3×10^{-3} m^3
    E) 7.4×10^{-4} m^3

18. A nanosecond is:
    A) 10^9 s
    B) 10^{-9} s
    C) 10^{-10} s
    D) 10^{-10} s
    E) 10^{-12} s

19. The SI base unit for mass is:
    A) gram
    B) pound
    C) kilogram
    D) ounce
    E) kilopound

20. 1 mi is equivalent to 1609 m so 55 mph is:
    A) 15 m/s
    B) 25 m/s
    C) 66 m/s
    D) 88 m/s
    E) 1500 m/s

Answer Key

1. D
2. B
3. D
4. B
5. E
6. E
7. B
8. D
9. C
10. C
11. C
12. C
13. B
14. D
15. E
16. B
17. D
18. B
19. C
20. B

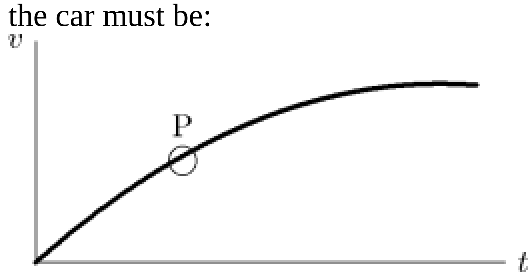
Name: ___________________________ Date: _____________

1. A car moving with an initial velocity of 25 m/s north has a constant acceleration of 3 m/s^2 south. After 6 seconds its velocity will be:
   A) 7 m/s north
   B) 7 m/s south
   C) 43 m/s north
   D) 20 m/s north
   E) 20 m/s south

2. A car starts from rest and goes down a slope with a constant acceleration of magnitude 5 m/s^2. After 5 s its speed, in meters per second, is:
   A) 1
   B) 12.5
   C) 25
   D) 50
   E) 160

3. The velocity of an object is given as a function of time by $\vec{v} = (4t - 3t^2)\hat{\imath}$, where $\vec{v}$ is in m/s and t is in seconds. Its average velocity over the interval from $t = 0$ to $t = 2$ s:
   A) is 0
   B) is (–2 m/s) $\hat{\imath}$
   C) is (2 m/s) $\hat{\imath}$
   D) is (–4 m/s) $\hat{\imath}$
   E) cannot be calculated unless the initial position is given

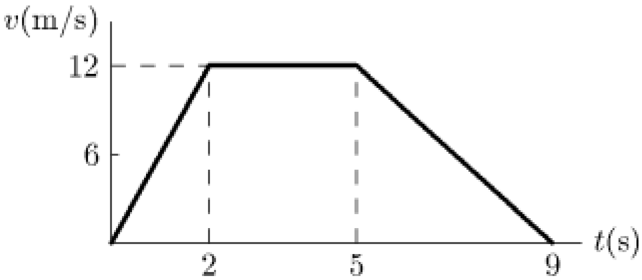
4. The diagram shows a velocity-time graph for a car moving in a straight line. At point P the car must be:



   A) moving with zero acceleration
   B) climbing the hill
   C) accelerating
   D) stationary
   E) moving at about 45° with respect to the x axis

5. A car travels 40 kilometers at an average speed of 80 km/h and then travels 40 kilometers at an average speed of 40 km/h. The average speed of the car for this 80-km trip is:
   A) 40 km/h
   B) 45 km/h
   C) 48 km/h
   D) 53 km/h
   E) 80 km/h

6. The diagram represents the straight line motion of a car. Which of the following statements is true?



   A) The car accelerates, stops, and reverses
   B) The car accelerates at 6 m/s^2 for the first 2 s
   C) The car is moving for a total time of 12 s
   D) The car decelerates at 12 m/s^2 for the last 4 s
   E) The car returns to its starting point when t = 9 s

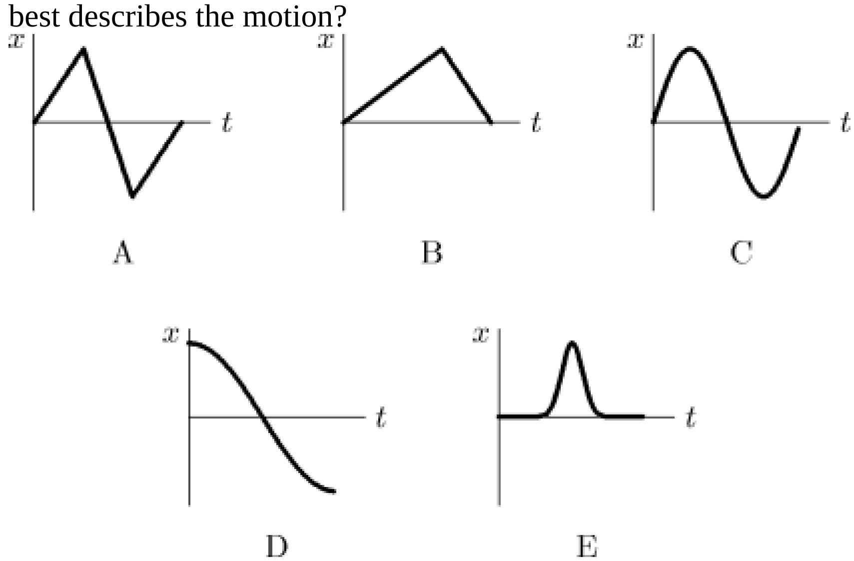
7. A racing car traveling with constant acceleration increases its speed from 10 m/s to 50 m/s over a distance of 60 m. How long does this take?
   A) 2.0 s
   B) 4.0 s
   C) 5.0 s
   D) 8.0 s
   E) The time cannot be calculated since the speed is not constant

8. The coordinate-time graph of an object is a straight line with a positive slope. The object has:
   A) constant displacement
   B) steadily increasing acceleration
   C) steadily decreasing acceleration
   D) constant velocity
   E) steadily increasing velocity

9. A particle moves along the x axis from x_1 to x_2. Of the following values of the initial and final coordinates, which results in the displacement with the largest magnitude?
   A) $x_1 = 4$ m, $x_2 = 6$ m
   B) $x_1 = –4$ m, $x_2 = –8$ m
   C) $x_1 = –4$ m, $x_2 = 2$ m
   D) $x_1 = 4$ m, $x_2 = –2$ m
   E) $x_1 = –4$ m, $x_2 = 4$ m

10. A particle moves along the x axis from x_1 to x_2. Of the following values of the initial and final coordinates, which results in a displacement that is in the negative x direction?
   A) $x_1 = 4$ m, $x_2 = 6$ m
   B) $x_1 = –4$ m, $x_2 = –8$ m
   C) $x_1 = –4$ m, $x_2 = 2$ m
   D) $x_1 = –4$ m, $x_2 = –2$ m
   E) $x_1 = –4$ m, $x_2 = 4$ m

11. A car accelerates from rest on a straight road. A short time later, the car decelerates to a stop and then returns to its original position in a similar manner, by first speeding up and then slowing to a stop. Which of the following five coordinate versus time graphs best describes the motion?



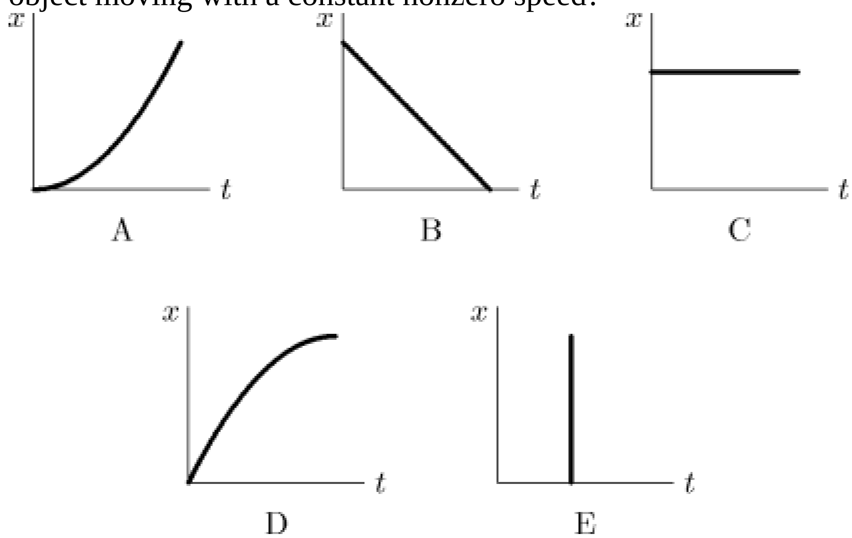
   A) A
   B) B
   C) C
   D) D
   E) E

12. Throughout a time interval, while the speed of a particle increases as it moves along the x axis, its velocity and acceleration:
    A) might be in the positive and negative x directions, respectively
    B) might be in the negative and positive x directions, respectively
    C) might both be in the negative x direction
    D) might be in the negative x direction and zero, respectively
    E) might be in the positive x direction and zero, respectively

13. At time $t = 0$ a car has a velocity of (16 m/s) $\hat{\imath}$. It slows down with an acceleration given by $(-0.50 \text{ m/s}^3)t\ \hat{\imath}$. By the time it stops it has traveled:
    A) 15 m
    B) 31 m
    C) 62 m
    D) 85 m
    E) 100 m

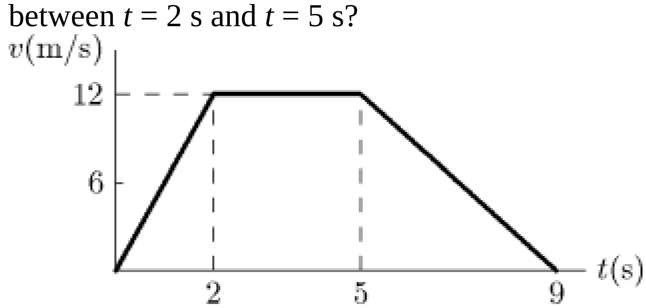
14. A car starts from Hither, goes 50 km in a straight line to Yon, immediately turns around, and returns to Hither. The time for this round trip is 2 hours. The average speed of the car for this round trip is:
    A) 0
    B) 50 km/h
    C) 100 km/h
    D) 200 km/h
    E) cannot be calculated without knowing the acceleration

15. Which of the following five coordinate versus time graphs represents the motion of an object moving with a constant nonzero speed?



A) A
B) B
C) C
D) D
E) E

16. The graph represents the straight line motion of a car. How far does the car travel between t = 2 s and t = 5 s?



A) 4 m
B) 12 m
C) 24 m
D) 36 m
E) 60 m

17. Over a short interval, starting at time $t = 0$, the coordinate of an automobile in meters is given by $x(t) = 27t - 4.0t^3$, where t is in seconds. The magnitudes of the initial (at $t = 0$) velocity and acceleration of the auto respectively are:
    A) 0; (12 m/s^2) î
    B) 0; (24 m/s^2) î
    C) (27 m/s) î; 0
    D) (27 m/s) î; (12 m/s^2) î
    E) (27 m/s) î; (24 m/s^2) î

18. A particle moves along the x axis according to the equation $x = 6t^2$, where x is in meters and t is in seconds. Therefore:
    A) the acceleration of the particle is (6 m/s^2) î
    B) t cannot be negative
    C) the particle follows a parabolic path
    D) each second the speed of the particle changes by 9.8 m/s
    E) none of the above

19. Two automobiles are 150 kilometers apart and traveling toward each other on a straight road. One automobile is moving at 60 km/h and the other is moving at 40 km/h mph. In how many hours will they meet?
    A) 2.5
    B) 2.0
    C) 1.75
    D) 1.5
    E) 1.25

20. Over a short interval near time $t = 0$ the coordinate of an automobile in meters is given by $x(t) = 27t - 4.0t^3$, where t is in seconds. At the end of 1.0 s the acceleration of the auto is:
    A) (27 m/s^2) î
    B) (4.0 m/s^2) î
    C) (–4.0 m/s^2) î
    D) (–12 m/s^2) î
    E) (–24 m/s^2) î

Answer Key

1. A
2. C
3. A
4. C
5. D
6. B
7. B
8. D
9. E
10. B
11. E
12. C
13. D
14. B
15. B
16. D
17. C
18. E
19. D
20. E

Name: ___________________________ Date: _____________

1. A ball is in free fall. Upward is taken to be the positive direction. The displacement of the ball during a short time interval is:
   A) positive during both ascent and descent
   B) negative during both ascent and descent
   C) negative during ascent and positive during descent
   D) positive during ascent and negative during descent
   E) none of the above

2. An object is thrown straight down with an initial speed of 4 m/s from a window which is 8 m above the ground. The time it takes the object to reach the ground is:
   A) 0.80 s
   B) 0.93 s
   C) 1.3 s
   D) 1.7 s
   E) 2.0 s

3. A car travels east at constant velocity. The net force on the car is:
   A) east
   B) west
   C) up
   D) down
   E) zero

4. A freely falling body has a constant acceleration with a magnitude of 9.8 m/s^2. This means that:
   A) the body falls 9.8 m during each second
   B) the body falls 9.8 m during the first second only
   C) the speed of the body increases by 9.8 m/s during each second
   D) the magnitude of the acceleration of the body increases by 9.8 m/s^2 during each second
   E) the magnitude of the acceleration of the body decreases by 9.8 m/s^2 during each second

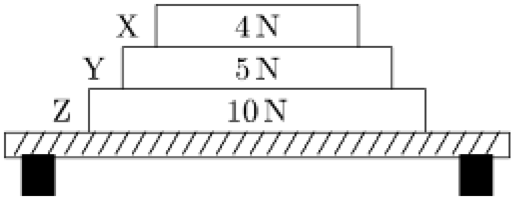
5. When a certain force is applied to the standard kilogram its acceleration is 5.0 m/s^2. When the same force is applied to another object its acceleration is one-fifth as much. The mass of the object is:
   A) 0.2 kg
   B) 0.5 kg
   C) 1.0 kg
   D) 5.0 kg
   E) 10 kg

6. An object dropped from the window of a tall building hits the ground in 12.0 s. If its acceleration has a magnitude of 9.80 m/s^2, the height of the window above the ground is:
   A) 29.4 m
   B) 58.8 m
   C) 118 m
   D) 353 m
   E) 706 m

7. One object is thrown vertically upward with an initial velocity of 100 m/s and another object with an initial velocity of 10 m/s. The maximum height reached by the first object will be ______ that of the other.
   A) 10 times
   B) 100 times
   C) 1000 times
   D) 10,000 times
   E) none of these

8. An object is thrown straight up from ground level with a speed of 50 m/s. If the magnitude of the local gravitational strength is g = 10 N/kg its distance above ground level 6.0 s later is:
   A) 0.00 m
   B) 270 m
   C) 330 m
   D) 480 m
   E) none of these

9. Three books (X, Y, and Z) rest on a table. The gravitational force on each book is indicated. The net force on book Y is:



   A) 4 N down
   B) 5 N up
   C) 9 N down
   D) zero
   E) none of these

10. A feather and a lead ball are dropped from rest in vacuum on the Moon. The acceleration of the feather is:
   A) more than that of the lead ball
   B) the same as that of the lead ball
   C) less than that of the lead ball
   D) 9.8 m/s^2
   E) zero since it floats in a vacuum

11. Acceleration is always in the direction:
   A) of the displacement
   B) of the initial velocity
   C) of the final velocity
   D) of the net force
   E) opposite to the frictional force

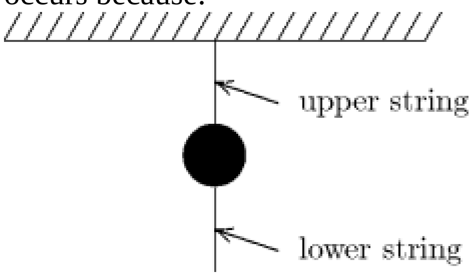
12. An example of an inertial reference frame is:
   A) any reference frame that is not accelerating
   B) a reference frame attached to a particle on which there are no forces
   C) any reference frame that is at rest
   D) a reference frame attached to the center of the universe
   E) a reference frame attached to Earth

13. An object rests on a horizontal frictionless surface. A horizontal force of magnitude F is applied. This force produces an acceleration:
   A) only if F is larger than the weight of the object
   B) only while the object suddenly changes from rest to motion
   C) always
   D) only if the inertia of the object decreases
   E) only if F is increasing

14. An object is thrown straight up from ground level with a speed of 50 m/s. If g = 10 m/s^2 its distance above ground level 1.0 s later is:
    A) 40 m
    B) 45 m
    C) 50 m
    D) 55 m
    E) 60 m

15. A lead block is suspended from your hand by a string. The reaction to the force of gravity on the block is the force exerted by:
    A) the string on the block
    B) the block on the string
    C) the string on the hand
    D) the hand on the string
    E) the block on Earth

16. A heavy ball is suspended as shown. A quick jerk on the lower string will break that string but a slow pull on the lower string will break the upper string. The first result occurs because:



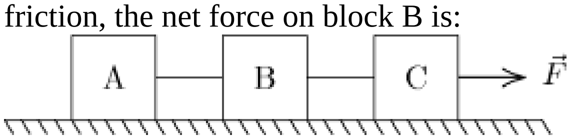
    A) the force is too small to move the ball
    B) action and reaction is operating
    C) the ball has inertia
    D) air friction holds the ball back
    E) the ball has too much energy

17. The unit of force called the newton is:
    A) 9.8 kg · m/s^2
    B) 1 kg · m/s^2
    C) defined by means of Newton's third law
    D) 1 kg of mass
    E) 1 kg of force

18. A newton is the force:
    A) of gravity on a 1 kg body
    B) of gravity on a 1 g body
    C) that gives a 1 g body an acceleration of 1 cm/s^2
    D) that gives a 1 kg body an acceleration of 1 m/s^2
    E) that gives a 1 kg body an acceleration of 9.8 m/s^2

19. A stone is released from rest from the edge of a building roof 190 m above the ground. Neglecting air resistance, the speed of the stone, just before striking the ground, is:
    A) 43 m/s
    B) 61 m/s
    C) 120 m/s
    D) 190 m/s
    E) 1400 m/s

20. Three blocks (A,B,C), each having mass *M*, are connected by strings as shown. Block C is pulled to the right by a force $\vec{F}$ that causes the entire system to accelerate. Neglecting friction, the net force on block B is:



    A) zero
    B) $\vec{F}/3$
    C) $\vec{F}/2$
    D) $2\vec{F}/3$
    E) $\vec{F}$

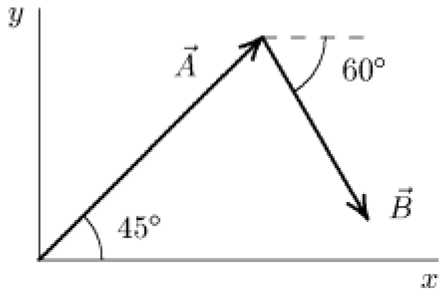
Answer Key

1. D
2. B
3. E
4. C
5. D
6. E
7. B
8. E
9. D
10. B
11. D
12. B
13. C
14. B
15. E
16. C
17. B
18. D
19. B
20. B

Name: ___________________________ Date: _____________

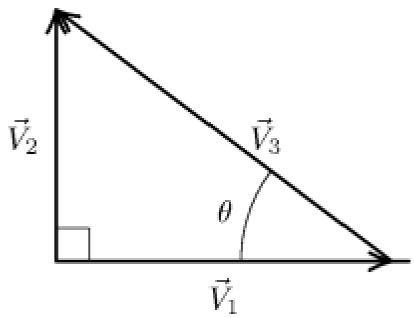
1. Vectors $\vec{A}$ and $\vec{B}$ lie in the *xy* plane. We can deduce that $\vec{A} = \vec{B}$ if:
   A) $A_x^2 + A_y^2 = B_x^2 + B_y^2$
   B) $A_x + A_y = B_x + B_y$
   C) $A_x = B_x$ and $A_y = B_y$
   D) $A_y/A_x = B_y/B_x$
   E) $A_x = A_y$ and $B_x = B_y$

2. In the diagram, $\vec{A}$ has magnitude 12 m and $\vec{B}$ has magnitude 8 m. The *x* component of $\vec{A}+\vec{B}$ is about:



   A) 5.5 m
   B) 7.6 m
   C) 12 m
   D) 14 m
   E) 15 m

3. The vector $\vec{V}_3$ in the diagram is equal to:



   A) $\vec{V}_1 - \vec{V}_2$
   B) $\vec{V}_1 + \vec{V}_2$
   C) $\vec{V}_2 - \vec{V}_1$
   D) $\vec{V}_1 \cos\theta$
   E) $\vec{V}_1 / (\cos\theta)$

4. A certain vector in the *xy* plane has an *x* component of 4 m and a *y* component of 10 m. It is then rotated in the *xy* plane so its *x* component is doubled. Its new *y* component is about:
   A) 20 m
   B) 7.2 m
   C) 5.0 m
   D) 4.5 m
   E) 2.2 m

5. If $\vec{A}=(2\,\text{m})\,\hat{\text{i}}-(3\,\text{m})\,\hat{\text{j}}$ and $\vec{B}=(1\,\text{m})\,\hat{\text{i}}-(2\,\text{m})\,\hat{\text{j}}$, then $\vec{A}-2\vec{B}=$
   A) $(1\,\text{m})\,\hat{\text{j}}$
   B) $(-1\,\text{m})\,\hat{\text{j}}$
   C) $(4\,\text{m})\,\hat{\text{i}}-(7\,\text{m})\,\hat{\text{j}}$
   D) $(4\,\text{m})\,\hat{\text{i}}+(1\,\text{m})\,\hat{\text{j}}$
   E) $(-4\,\text{m})\,\hat{\text{i}}+(7\,\text{m})\,\hat{\text{j}}$

6. In the expressions $\vec{r}=x\,\hat{\text{i}}+y\,\hat{\text{j}}$ for the position vector of a particle and $\vec{v}=v_x\,\hat{\text{i}}+v_y\,\hat{\text{j}}$ for its velocity:
   A) the unit vector $\hat{\text{i}}$ might have a unit of meters
   B) $\hat{\text{i}}$ and $\hat{\text{j}}$ are both variables
   C) $\hat{\text{i}}$ represents a different vector in the two expressions
   D) $\hat{\text{i}}$ and $\hat{\text{j}}$ are parallel to each other
   E) none of the above

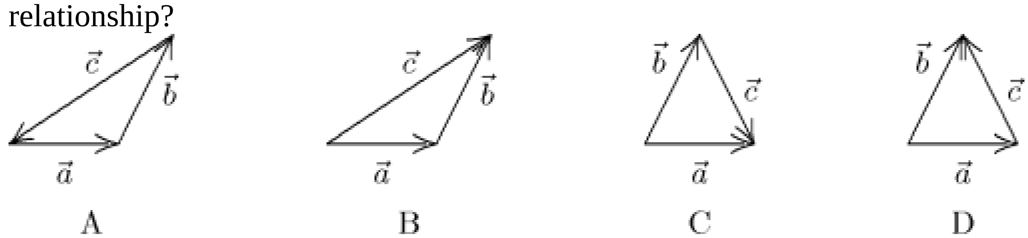
7. The angle between $\vec{A}=(25\,\text{m})\,\hat{\text{i}}+(45\,\text{m})\,\hat{\text{j}}$ and the positive *x* axis is:
   A) 29º
   B) 61º
   C) 151º
   D) 209º
   E) 241º

8. Let $\vec{A}=(2\,\text{m})\,\hat{\text{i}}+(6\,\text{m})\,\hat{\text{j}}-(3\,\text{m})\,\hat{\text{k}}$ and $\vec{B}=(4\,\text{m})\,\hat{\text{i}}+(2\,\text{m}\,\hat{\text{j}}+(1\,\text{m})\,\hat{\text{k}}$. The vector difference $\vec{D}=\vec{A}-\vec{B}$ is:
   A) $(6\,\text{m})\,\hat{\text{i}}+(8\,\text{m})\,\hat{\text{j}}-(2\,\text{m})\,\hat{\text{k}}$
   B) $(-2\,\text{m})\,\hat{\text{i}}+(4\,\text{m})\,\hat{\text{j}}-(4\,\text{m})\,\hat{\text{k}}$
   C) $(2\,\text{m})\,\hat{\text{i}}-(4\,\text{m})\,\hat{\text{j}}+(4\,\text{m})\,\hat{\text{k}}$
   D) $(8\,\text{m})\,\hat{\text{i}}+(12\,\text{m})\,\hat{\text{j}}-(3\,\text{m})\,\hat{\text{k}}$
   E) none of these

9. A vector has a component of 10 m in the $+x$ direction, a component of 10 m in the $+y$ direction, and a component of 5 m in the $+z$ direction. The magnitude of this vector is:
   A) zero
   B) 15 m
   C) 20 m
   D) 25 m
   E) 225 m

10. The angle between $\vec{A}=(-25\,\text{m})\,\hat{\text{i}}+(45\,\text{m})\,\hat{\text{j}}$ and the positive x axis is:
   A) 29°
   B) 61°
   C) 119°
   D) 151°
   E) 209°

11. The vectors $\vec{a}$, $\vec{b}$, and $\vec{c}$ are related by $\vec{c}=\vec{b}-\vec{a}$. Which diagram below illustrates this relationship?



   A) A
   B) B
   C) C
   D) D
   E) None of these

12. If $|\vec{A}+\vec{B}|^2 = A^2 + B^2$, then:

A) $\vec{A}$ and $\vec{B}$ must be parallel and in the same direction
B) $\vec{A}$ and $\vec{B}$ must be parallel and in opposite directions
C) either $\vec{A}$ or $\vec{B}$ must be zero
D) the angle between $\vec{A}$ and $\vec{B}$ must be 60º
E) none of the above is true

13. A vector in the *xy* plane has a magnitude of 25 m and an *x* component of 12 m. The angle it makes with the positive *x* axis is:

A) 26º
B) 29º
C) 61º
D) 64º
E) 241º

14. Let $\vec{V} = (2.00\,\mathrm{m})\,\hat{\mathrm{i}} + (6.00\,\mathrm{m})\,\hat{\mathrm{j}} - (3.00\,\mathrm{m})\,\hat{\mathrm{k}}$. The magnitude of $\vec{V}$ is:

A) 5.00 m
B) 5.57 m
C) 7.00 m
D) 7.42 m
E) 8.54 m

15. If $|\vec{A}+\vec{B}| = A + B$ and neither $\vec{A}$ nor $\vec{B}$ vanish, then:

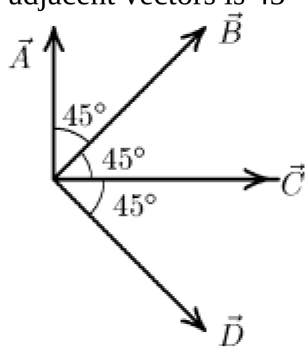
A) $\vec{A}$ and $\vec{B}$ are parallel and in the same direction
B) $\vec{A}$ and $\vec{B}$ are parallel and in opposite directions
C) the angle between $\vec{A}$ and $\vec{B}$ is 45º
D) the angle between $\vec{A}$ and $\vec{B}$ is 60º
E) $\vec{A}$ is perpendicular to $\vec{B}$

16. Let $\vec{A} = (2\,\mathrm{m})\,\hat{\mathrm{i}} + (6\,\mathrm{m})\,\hat{\mathrm{j}} - (3\,\mathrm{m})\,\hat{\mathrm{k}}$ and $\vec{B} = (4\,\mathrm{m})\,\hat{\mathrm{i}} + (2\,\mathrm{m})\,\hat{\mathrm{j}} + (1\,\mathrm{m})\,\hat{\mathrm{k}}$. The vector sum $\vec{S} = \vec{A} + \vec{B}$ is:

A) $(6\,\mathrm{m})\,\hat{\mathrm{i}} + (8\,\mathrm{m})\,\hat{\mathrm{j}} - (2\,\mathrm{m})\,\hat{\mathrm{k}}$
B) $(-2\,\mathrm{m})\,\hat{\mathrm{i}} + (4\,\mathrm{m})\,\hat{\mathrm{j}} - (4\,\mathrm{m})\,\hat{\mathrm{k}}$
C) $(2\,\mathrm{m})\,\hat{\mathrm{i}} - (4\,\mathrm{m})\,\hat{\mathrm{j}} + (4\,\mathrm{m})\,\hat{\mathrm{k}}$
D) $(8\,\mathrm{m})\,\hat{\mathrm{i}} + (12\,\mathrm{m})\,\hat{\mathrm{j}} - (3\,\mathrm{m})\,\hat{\mathrm{k}}$
E) none of these

17. A vector of magnitude 3 CANNOT be added to a vector of magnitude 4 so that the magnitude of the resultant is:
    A) zero
    B) 1
    C) 3
    D) 5
    E) 7

18. Four vectors ($\vec{A}$, $\vec{B}$, $\vec{C}$, $\vec{D}$) all have the same magnitude. The angle θ between adjacent vectors is 45º as shown. The correct vector equation is:



    A) $\vec{A}-\vec{B}-\vec{C}+\vec{D}=0$
    B) $\vec{B}+\vec{D}-\sqrt{2}\vec{C}=0$
    C) $\vec{A}+\vec{B}=\vec{B}+\vec{D}$
    D) $\vec{A}+\vec{B}+\vec{C}+\vec{D}=0$
    E) $(\vec{A}+\vec{C})/\sqrt{2}=-\vec{B}$

19. We say that the displacement of a particle is a vector quantity. Our best justification for this assertion is:
    A) displacement can be specified by a magnitude and a direction
    B) operating with displacements according to the rules for manipulating vectors leads to results in agreement with experiments
    C) a displacement is obviously not a scalar
    D) displacement can be specified by three numbers
    E) displacement is associated with motion

20. If $\vec{A}=(6\,\text{m})\,\hat{\imath}-(8\,\text{m})\,\hat{\jmath}$ then $4\vec{A}$ has magnitude:
    A) 10 m
    B) 20 m
    C) 30 m
    D) 40 m
    E) 50 m

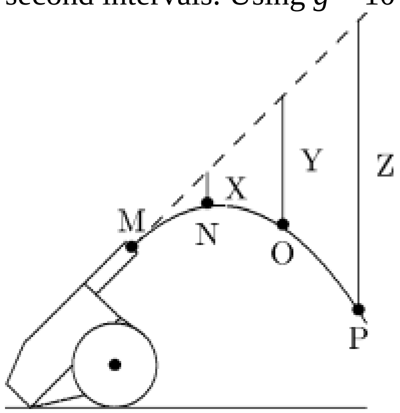
Answer Key

1. C
2. C
3. C
4. B
5. A
6. E
7. B
8. B
9. B
10. C
11. D
12. E
13. C
14. C
15. A
16. A
17. A
18. B
19. B
20. D

Name: ____________________________ Date: ______________

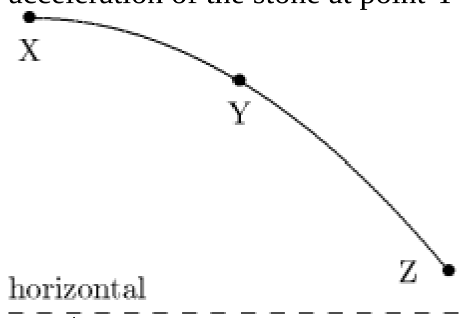
1. A boy on the edge of a vertical cliff 20 m high throws a stone horizontally outward with a speed of 20 m/s. It strikes the ground at what horizontal distance from the foot of the cliff? Use g = 10 m/s^2.
   A) 10 m
   B) 40 m
   C) 50 m
   D) $50\sqrt{5}$ m
   E) none of these

2. A cannon fires a projectile as shown. The dashed line shows the trajectory in the absence of gravity; points MNOP correspond to the positions of the particle at one second intervals. Using g = 10 N/kg, the lengths X,Y,Z are:



   A) 5 m, 10 m, 15 m
   B) 5 m, 20 m, 45 m
   C) 10 m, 40 m, 90 m
   D) 10 m, 20 m, 30 m
   E) 0.2 m, 0.8 m, 1.8 m

3. A stone is thrown horizontally and follows the path XYZ shown. The direction of the acceleration of the stone at point Y is:



A) $\downarrow$
B) $\rightarrow$
C) $\searrow$
D) $\swarrow$
E) $\nearrow$

4. A particle moves at constant speed in a circular path. The instantaneous velocity and instantaneous acceleration vectors are:
A) both tangent to the circular path
B) both perpendicular to the circular path
C) perpendicular to each other
D) opposite to each other
E) none of the above

5. A stone thrown from the top of a tall building follows a path that is:
A) circular
B) made of two straight line segments
C) hyperbolic
D) parabolic
E) a straight line

6. An object is shot from the back of a railroad flatcar moving at 40 km/h on a straight horizontal road. The launcher is aimed upward, perpendicular to the bed of the flatcar. The object falls:
A) in front of the flatcar
B) behind the flatcar
C) on the flatcar
D) either behind or in front of the flatcar, depending on the initial speed of the object
E) to the side of the flatcar

7. A stone is thrown outward from the top of a 59.4-m high cliff with an upward velocity component of 19.5 m/s. How long is the stone in the air?
   A) 4 s
   B) 5 s
   C) 6 s
   D) 7 s
   E) 8 s

8. A car rounds a 20-m radius curve at 10 m/s. The magnitude of its acceleration in is:
   A) 0
   B) 0.20 m/s^2
   C) 5.0 m/s^2
   D) 40 m/s^2
   E) 400 m/s^2

9. A bullet shot horizontally from a gun:
   A) strikes the ground much later than one dropped vertically from the same point at the same instant
   B) never strikes the ground
   C) strikes the ground at approximately the same time as one dropped vertically from the same point at the same instant
   D) travels in a straight line
   E) strikes the ground much sooner than one dropped from the same point at the same instant

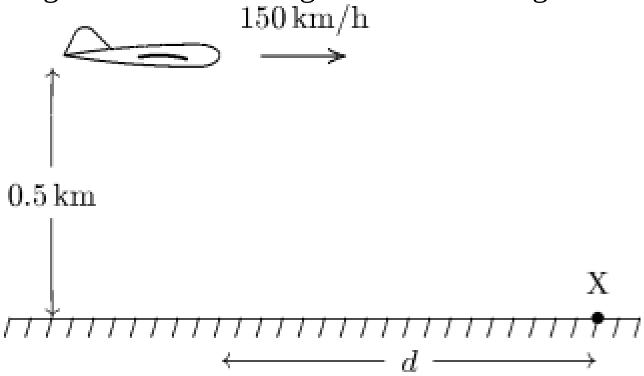
10. Acceleration is defined as:
    A) rate of change of position with time
    B) speed divided by time
    C) rate of change of velocity with time
    D) a speeding up or slowing down
    E) change of velocity

11. An object is moving on a circular path of radius π meters at a constant speed of 4.0 m/s. The time required for one revolution is:
    A) $2/\pi^2$ s
    B) $\pi^2/2$ s
    C) $\pi/2$ s
    D) $\pi^2/4$ s
    E) $2/\pi$ s

12. An object moving in a circle at constant speed:
   A) must have only one force acting on it
   B) is not accelerating
   C) is held to its path by centrifugal force
   D) has an acceleration of constant magnitude
   E) has an acceleration that is tangent to the circle

13. An airplane is flying north at 500 km/h. It makes a gradual 180º turn at constant speed, changing its direction of travel from north through east to south. The process takes 40 s. The average acceleration of the plane for this turn is:
   A) 12.5 m/s^2, north
   B) 12.5 m/s^2, east
   C) 12.5 m/s^2, south
   D) 25 m/s^2, north
   E) 25 m/s^2, south

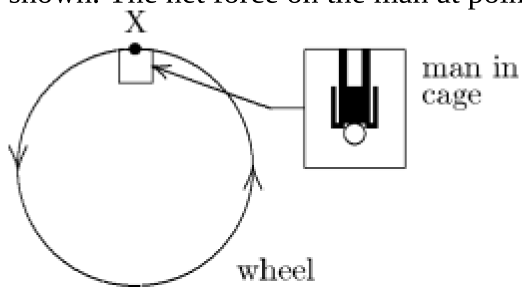
14. The airplane shown is in level flight at an altitude of 0.50 km and a speed of 150 km/h. At what distance *d* should it release a heavy package to hit the target X? Take the magnitude of the local gravitational strength to be 10 N/kg^2.



   A) 150 m
   B) 295 m
   C) 420 m
   D) 2550 m
   E) 15,000 m

15. If a certain car, going with speed v_1, rounds a level curve with a radius R_1, it is just on the verge of skidding. If its speed is now doubled, the radius of the tightest curve on the same road, with the same force on the car, that it can round is:
    A) $2R_1$
    B) $4R_1$
    C) $R_1/2$
    D) $R_1/4$
    E) R_1

16. A giant wheel, having a diameter of 40 m, is fitted with a cage and platform on which a man of mass *m* stands. The wheel is rotated in a vertical plane at such a speed that the force exerted by the man on the platform is equal to his weight when the cage is at X, as shown. The net force on the man at point X is:



    A) zero
    B) *mg*, down
    C) *mg*, up
    D) 2*mg*, down
    E) 2*mg*, up

17. A large cannon is fired from ground level over level ground at an angle of 30º above the horizontal. The muzzle speed is 980 m/s. Neglecting air resistance, the projectile will travel what horizontal distance before striking the ground?
    A) 4.3 km
    B) 8.5 km
    C) 43 km
    D) 85 km
    E) 170 km

18. An airplane makes a gradual 90º turn while flying at a constant speed of 200 m/s. The process takes 20.0 seconds to complete. For this turn the magnitude of the average acceleration of the plane is:
    A) zero
    B) 40 m/s^2
    C) 20 m/s^2
    D) 14 m/s^2
    E) 10 m/s^2

19. Two bodies are falling with negligible air resistance, side by side, above a horizontal plane. If one of the bodies is given an additional horizontal acceleration during its descent, it:
    A) strikes the plane at the same time as the other body
    B) strikes the plane earlier than the other body
    C) has the vertical component of its velocity altered
    D) has the vertical component of its acceleration altered
    E) follows a straight line path along the resultant acceleration vector

20. A stone is tied to the end of a string and is swung with constant speed around a horizontal circle with a radius of 1.5 m. If it makes two complete revolutions each second, the magnitude of its acceleration is:
    A) 0.24 m/s^2
    B) 2.4 m/s^2
    C) 24 m/s^2
    D) 240 m/s^2
    E) 2400 m/s^2

Answer Key

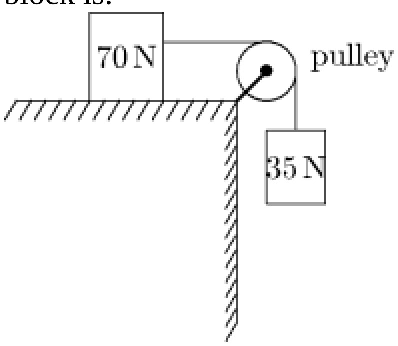
1. B
2. B
3. A
4. C
5. D
6. C
7. C
8. C
9. C
10. C
11. B
12. D
13. E
14. C
15. B
16. D
17. D
18. D
19. A
20. D

Name: ___________________________ Date: _____________

1. A crate resting on a rough horizontal floor is to be moved horizontally. The coefficient of static friction is 0.40. To start the crate moving with the weakest possible applied force, in what direction should the force be applied?

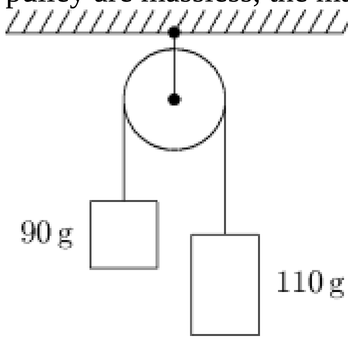
A) Horizontal
B) 24º below the horizontal
C) 22º above the horizontal
D) 24º above the horizontal
E) 66º below the horizontal

2. A 70-N block and a 35-N block are connected by a string as shown. If the pulley is massless and the surface is frictionless, the magnitude of the acceleration of the 35-N block is:



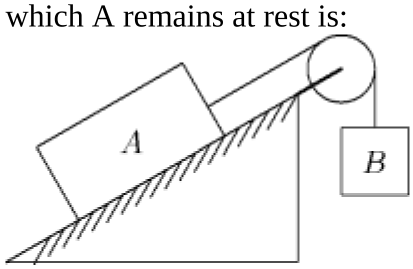
A) 1.6 m/s^2
B) 3.3 m/s^2
C) 4.9 m/s^2
D) 6.7 m/s^2
E) 9.8 m/s^2

3. Two blocks are connected by a string and pulley as shown. Assuming that the string and pulley are massless, the magnitude of the acceleration of each block is:



A) 0.049 m/s^2
B) 0.020 m/s^2
C) 0.0098 m/s^2
D) 0.54 m/s^2
E) 0.98 m/s^2

4. Block A, with a mass of 10 kg, rests on a 35º incline. The coefficient of static friction is 0.40. An attached string is parallel to the incline and passes over a massless, frictionless pulley at the top. The largest mass m_B of block B, attached to the dangling end, for which A remains at rest is:



A) 2.5 kg
B) 3.5 kg
C) 5.9 kg
D) 9.0 kg
E) 10.5 kg

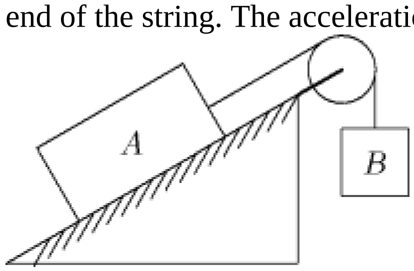
5. When a 40-N force, parallel to the incline and directed up the incline, is applied to a crate on a frictionless incline that is 30º above the horizontal, the acceleration of the crate is 2.0 m/s^2, up the incline. The mass of the crate is:

A) 3.8 kg
B) 4.1 kg
C) 5.8 kg
D) 6.2 kg
E) 10 kg

6. A 90-kg man stands in an elevator that has a downward acceleration of 1.4 m/s^2. The force exerted by him on the floor is about:

A) zero
B) 90 N
C) 760 N
D) 880 N
E) 1010 N

7. Block A, with a mass of 10 kg, rests on a 30º incline. The coefficient of kinetic friction is 0.20. The attached string is parallel to the incline and passes over a massless, frictionless pulley at the top. Block B, with a mass of 8.0 kg, is attached to the dangling end of the string. The acceleration of B is:

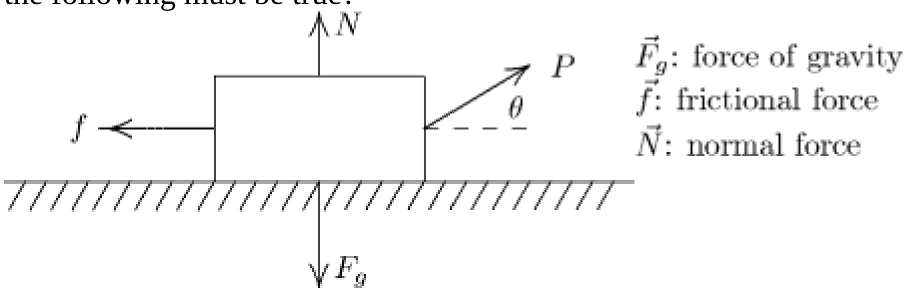


A) 0.69 m/s^2, up the plane
B) 0.69 m/s^2, down the plane
C) 2.6 m/s^2, up the plane
D) 2.6 m/s^2, down the plane
E) 0

8. A force $\vec{F}$ (larger than the largest possible force of static friction) is applied to the left to an object moving to the right on a horizontal surface. Then:

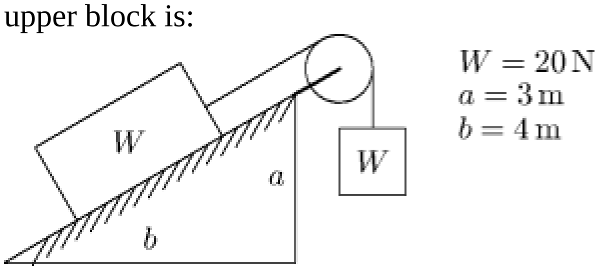
A) the object must be moving at constant speed
B) $\vec{F}$ and the friction force act in opposite directions
C) the object must be slowing down
D) the object must be speeding up
E) the object must come to rest and remain at rest

9. A boy pulls a wooden box along a rough horizontal floor at constant speed by means of a force $\vec{P}$ as shown. In the diagram f is the magnitude of the force of friction, N is the magnitude of the normal force, and F_g is the magnitude of the force of gravity. Which of the following must be true?



A) $P = f$ and $N = F_g$
B) $P = f$ and $N > F_g$
C) $P > f$ and $N < F_g$
D) $P > f$ and $N = F_g$
E) none of these

10. The system shown remains at rest. Each block weighs 20 N. The force of friction on the upper block is:



A) 4 N
B) 8 N
C) 12 N
D) 16 N
E) 20 N

11. A 25-kg crate is pushed across a frictionless horizontal floor with a force of 20 N, directed 20º below the horizontal. The acceleration of the crate is:

A) 0.27 m/s^2
B) 0.75 m/s^2
C) 0.80 m/s^2
D) 170 m/s^2
E) 470 m/s^2

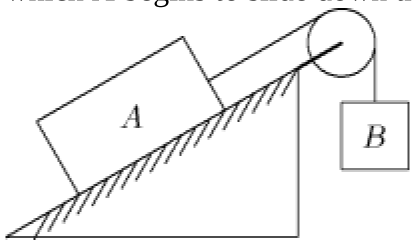
12. A car is traveling at 15 m/s on a horizontal road. The brakes are applied and the car skids to a stop in 4.0 s. The coefficient of kinetic friction between the tires and road is:

A) 0.38
B) 0.69
C) 0.76
D) 0.92
E) 1.11

13. A horizontal force of 5.0 N pushes a 0.50-kg book against a vertical wall. The book is initially at rest. If $\mu^{static} = 0.6$ and $\mu^{kin} = 0.80$ are the coefficients of friction, the magnitude of the frictional force is:

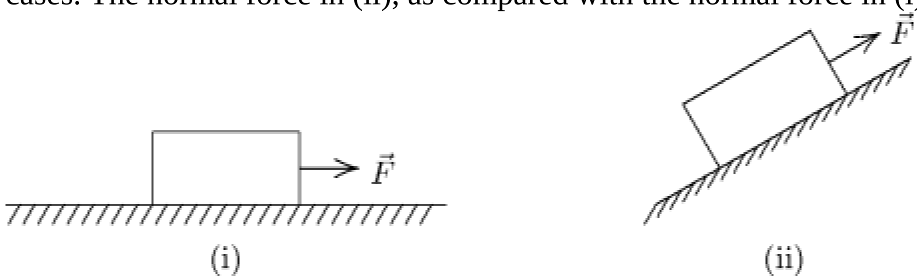
A) 0
B) 4.9 N
C) 3.0 N
D) 5.0 N
E) 4.0 N

14. Block A, with a mass of 10 kg, rests on a 35° incline. The coefficient of static friction is 0.40. An attached string is parallel to the incline and passes over a massless, frictionless pulley at the top. The largest mass m_B of block B, attached to the dangling end, for which A begins to slide down the incline is:



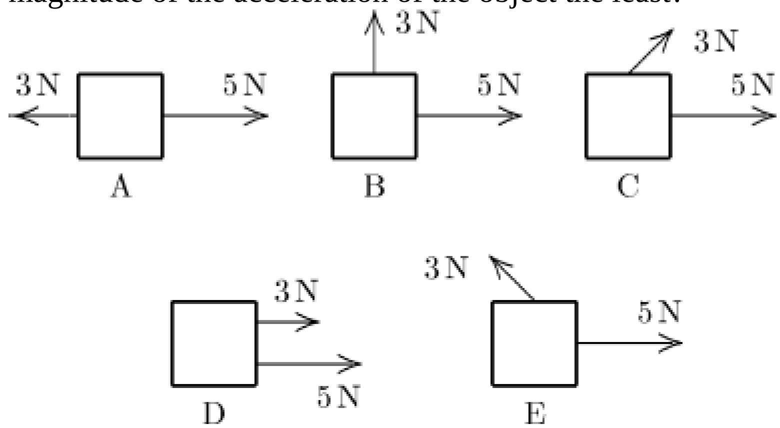
A) 2.5 kg
B) 3.5 kg
C) 5.9 kg
D) 9.0 kg
E) 10.5 kg

15. A heavy wooden block is dragged by a force $\vec{F}$ along a rough steel plate, as shown in the diagrams for two cases. The magnitude of the applied force $\vec{F}$ is the same for both cases. The normal force in (ii), as compared with the normal force in (i) is:



A) the same
B) greater
C) less
D) less for some angles of the incline and greater for others
E) less or greater, depending on the magnitude of the applied force $\vec{F}$.

16. Two forces, one with a magnitude of 3 N and the other with a magnitude of 5 N, are applied to an object. For which orientations of the forces shown in the diagrams is the magnitude of the acceleration of the object the least?



A) A
B) B
C) C
D) D
E) E

17. A car rounds a 75-m radius curve at a constant speed of 18 m/s. A ball is suspended by a string from the ceiling the car and moves with the car. The angle between the string and the vertical is:

A) 0
B) 1.4º
C) 24º
D) 90º
E) cannot be found without knowing the mass of the ball

18. A brick slides on a horizontal surface. Which of the following will increase the frictional force on it?

A) Putting a second brick on top
B) Decreasing the surface area of contact
C) Increasing the surface area of contact
D) Decreasing the mass of the brick
E) None of the above

19. A crate is sliding down an incline that is 35º above the horizontal. If the coefficient of kinetic friction is 0.40, the acceleration of the crate is:

A) 0
B) 2.4 m/s^2
C) 5.8 m/s^2
D) 8.8 m/s^2
E) 10.3 m/s^2

20. A ball is thrown upward into the air with a speed that is greater than terminal speed. It lands at the place where it was thrown. During its flight the force of air resistance is the greatest:

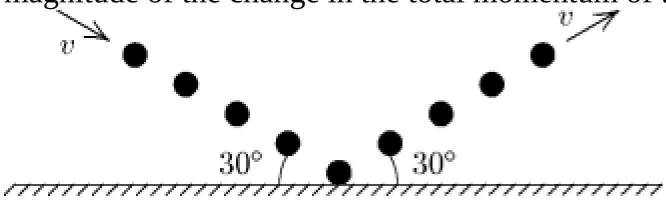
A) just after it is thrown
B) halfway up
C) at the top of its trajectory
D) halfway down
E) just before it lands.

Answer Key

1. C
2. B
3. E
4. D
5. C
6. C
7. B
8. C
9. C
10. B
11. B
12. A
13. E
14. A
15. C
16. A
17. C
18. A
19. B
20. A

Name: __________________________ Date: _____________

1. A stream of gas consists of n molecules. Each molecule has mass m and speed v. Each molecule is reflected without change in speed from a rigid surface as shown. The magnitude of the change in the total momentum of the stream is:



A) $2mnv$
B) $2mnv \sin 30^{o}$
C) $mnv \sin 30^{o}$
D) $mnv \cos 30^{o}$
E) mnv

2. A golf ball of mass m is hit by a golf club so that the ball leaves the tee with speed v. The club is in contact with the ball for time T. The magnitude of the average force on the club on the ball during the time T is:

A) mvT
B) mv/T
C) $(1/2)mv^2T$
D) $mv^2/(2T)$
E) $mT^2/(2v)$

3. A 0.2-kg rubber ball is dropped from the window of a building. It strikes the sidewalk below at 30 m/s and rebounds up at 20 m/s. The impulse on the ball during the collision is:

A) 10 N · s upward
B) 10 N · s downward
C) 2.0 N · s upward
D) 2.0 N · s downward
E) 9.8 N · s upward

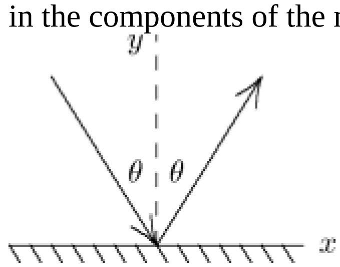
4. The thrust of a rocket is:

A) a gravitational force acting on the rocket
B) the force of the exiting fuel gases on the rocket
C) any force that is external to the rocket-fuel system
D) a force that arises from the reduction in mass of the rocket-fuel system
E) none of the above

5. A 64-kg woman stands on frictionless level ice, with a 0.10-kg stone at her feet. She kicks the stone with her foot so that she acquires a velocity of 0.0017 m/s in the forward direction. The velocity acquired by the stone is:

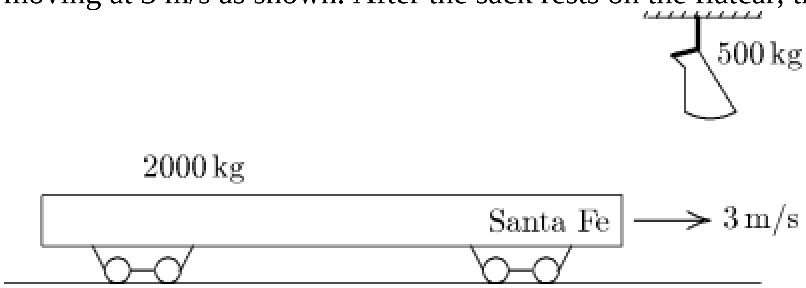
A) 1.1 m/s forward
B) 1.1 m/s backward
C) 0.0017 m/s forward
D) 0.0017 m/s backward
E) none of these

6. A ball hits a wall and rebounds with the same speed, as diagramed below. The changes in the components of the momentum of the ball are:



A) $\Delta p_x > 0, \Delta p_y > 0$
B) $\Delta p_x < 0, \Delta p_y > 0$
C) $\Delta p_x = 0, \Delta p_y > 0$
D) $\Delta p_x = 0, \Delta p_y < 0$
E) $\Delta p_x > 0, \Delta p_y < 0$

7. A 500-kg sack of coal is dropped on a 2000-kg railroad flatcar which was initially moving at 3 m/s as shown. After the sack rests on the flatcar, the speed of the flatcar is:



A) 0.6 m/s
B) 1.2 m/s
C) 1.8 m/s
D) 2.4 m/s
E) 3.6 m/s

8. Bullets from two revolvers are fired with the same velocity. The bullet from gun #1 is twice as heavy as the bullet from gun #2. Gun #1 weighs three times as much as gun #2. The ratio of the momentum imparted to gun #1 to that imparted to gun #2 is:

A) 2:3
B) 3:2
C) 2:1
D) 3:1
E) 6:1

9. What impulse will give a 2.0-kg object a momentum change of $+\ (50\,\mathrm{kg\cdot m/s})\,\hat{\mathrm{i}}$?

A) $+(25\,\mathrm{N\cdot s})\,\hat{\mathrm{i}}$
B) $-(25\,\mathrm{N\cdot s})\,\hat{\mathrm{i}}$
C) $+(50\,\mathrm{N\cdot s})\,\hat{\mathrm{i}}$
D) $-(50\,\mathrm{N\cdot s})\,\hat{\mathrm{i}}$
E) $+(100\,\mathrm{N\cdot s})\,\hat{\mathrm{i}}$

10. A 3.00-g bullet traveling horizontally at 400 m/s hits a 3.00-kg wooden block, which is initially at rest on a smooth horizontal table. The bullet buries itself in the block without passing through. The speed of the block after the collision is:

A) 1.33 m/s
B) 0.40 m/s
C) 12.0 m/s
D) 40.0 m/s
E) 160 m/s

11. A rifle of mass M is initially at rest but free to recoil. It fires a bullet of mass m and velocity v (relative to the ground). After firing, the velocity of the rifle (relative to the ground) is:

A) $-mv$
B) $-Mv/m$
C) $-mv/M$
D) $-v$
E) mv/M

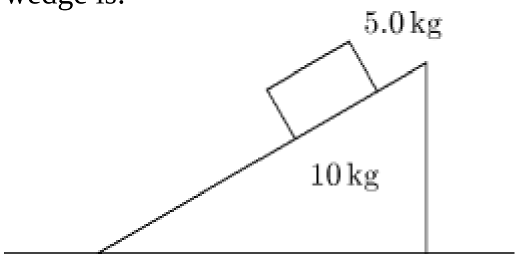
12. A 75-kg man is riding in a 30-kg cart at 2.0 m/s. He jumps off in such a way as to land on the ground with no horizontal velocity. The resulting change in speed of the cart is:

A) zero
B) 2.0 m/s
C) 3.0 m/s
D) 5.0 m/s
E) 7.0 m/s

13. A man is marooned at rest on level frictionless ice. In desperation, he hurls his shoe to the right at 15 m/s. If the man weighs 720 N and the shoe weighs 4.0 N, the man moves to the left with a speed of:

A) 0
B) 2.1×10^{-2} m/s
C) 8.3×10^{-2} m/s
D) 15 m/s
E) 2.7×10^{3} m/s

14. A large wedge with a mass of 10 kg rests on a horizontal frictionless surface, as shown. A block with a mass of 5.0 kg starts from rest and slides down the inclined surface of the wedge, which is rough. At one instant the vertical component of the block's velocity is 3.0 m/s and the horizontal component is 6.0 m/s. At that instant the velocity of the wedge is:



A) 3.0 m/s to the left
B) 3.0 m/s to the right
C) 6.0 m/s to the right
D) 6.0 m/s to the left
E) 17 m/s to the right

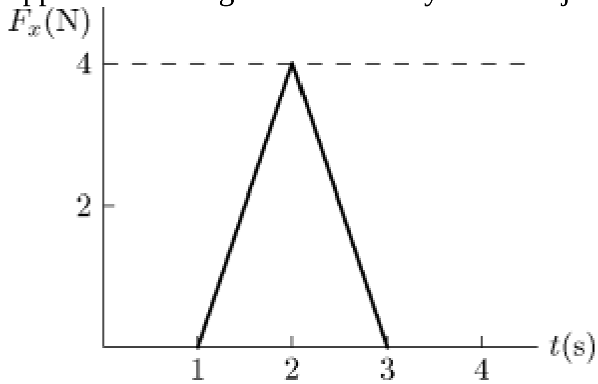
15. A 640-N acrobat falls 5.0 m from rest into a net. The net tosses him back up with the same speed he had just before he hit the net. The magnitude of the average upward force exerted on him by the net during this collision is:

A) 32 N
B) 64 N
C) 320 N
D) 640 N
E) impossible to determine from the given data

16. When you step on the accelerator to increase the speed of your car, the force that accelerates the car is:

A) the force of your foot on the accelerator
B) the force of friction of the road on the tires
C) the force of the engine on the drive shaft
D) the normal force of the road on the tires
E) none of the above

17. A 5-kg object can move along the x axis. It is subjected to a force $\vec{F}$ in the positive x direction; a graph of F_x as a function of time t is shown below. Over the time the force is applied the change in the velocity of the object is:



A) 0.8 m/s
B) 1.1 m/s
C) 1.6 m/s
D) 2.3 m/s
E) 4.0 m/s

18. At one instant of time a rocket is traveling in outer space at 2500 m/s and is exhausting fuel at a rate of 100 kg/s. If the speed of the fuel as it leaves the rocket is 1500 m/s, relative to the rocket, the thrust is:

A) 0
B) 1.0×10^5 N
C) 1.5×10^5 N
D) 2.9×10^5 N
E) 2.5×10^5 N

19. The momentum of an object at a given instant is independent of its:

A) inertia
B) mass
C) speed
D) velocity
E) acceleration

20. The physical quantity “impulse” has the same dimensions as that of:

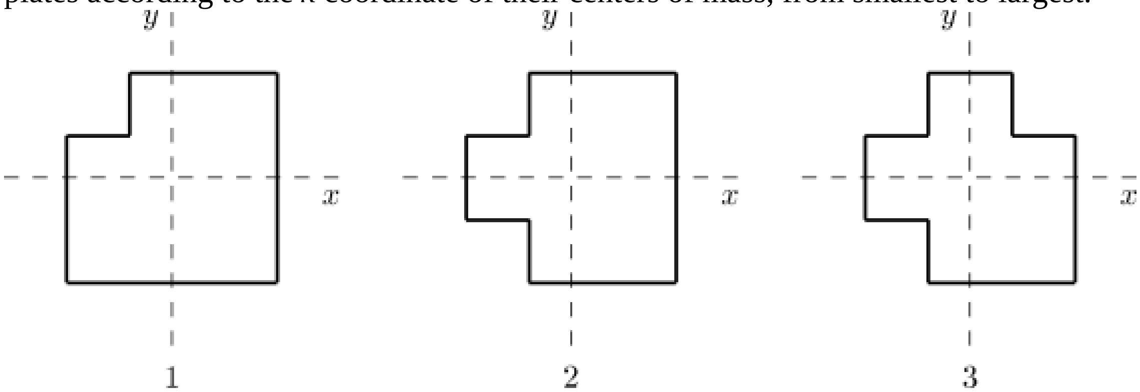
A) force
B) power
C) energy
D) momentum
E) work

Answer Key

1. B
2. B
3. A
4. B
5. B
6. C
7. D
8. C
9. C
10. B
11. C
12. D
13. C
14. B
15. E
16. B
17. A
18. C
19. E
20. D

Name: ___________________________ Date: _____________

1. A machinist starts with three identical square plates but cuts one corner from one of them, two corners from the second, and three corners from the third. Rank the three plates according to the *x* coordinate of their centers of mass, from smallest to largest.



A) 1, 2, 3
B) 1 and 2 tie, then 3
C) 1, then 2 and 3 tie
D) 3, 2, 1
E) 1 and 3 tie, then 2

2. At the same instant that a 0.50-kg ball is dropped from 25 m above Earth, a second ball, with a mass of 0.25 kg, is thrown straight upward from Earth's surface with an initial speed of 15 m/s. They move along nearby lines and pass each other without colliding. At the end of 2.0 s the height above Earth's surface of the center of mass of the two-ball system is:

A) 2.9 m
B) 4.0 m
C) 5.0 m
D) 7.1 m
E) 10.4 m

3. Two boys, with masses of 40 kg and 60 kg, respectively, stand on a horizontal frictionless surface holding the ends of a light 10-m long rod. The boys pull themselves together along the rod. When they meet the 60-kg boy will have moved what distance?

A) 4 m
B) 5 m
C) 6 m
D) 10 m
E) need to know the forces they exert

4. A 640-N hunter gets a rope around a 3200-N polar bear. They are stationary, 20 m apart, on frictionless level ice. When the hunter pulls the polar bear to him, the polar bear will move:

A) 1.0 m
B) 3.3 m
C) 10 m
D) 12 m
E) 17 m

5. At the same instant that a 0.50-kg ball is dropped from 25 m above Earth, a second ball, with a mass of 0.25 kg, is thrown straight upward from Earth's surface with an initial speed of 15 m/s. They move along nearby lines and pass without colliding. At the end of 2.0 s the magnitude of the acceleration of the center of mass of the two-ball system is:

A) $0.25g$
B) $0.50g$
C) $0.75g$
D) g
E) $g/0.75$

6. A light rope passes over a light frictionless pulley attached to the ceiling. An object with a large mass is tied to one end and an object with a smaller mass is tied to the other end. Starting from rest the heavier object moves downward and the lighter object moves upward with the same magnitude acceleration. Which of the following statements is true for the system consisting of the two objects?

A) The center of mass remains at rest.
B) The net external force is zero.
C) The velocity of the center of mass is a constant.
D) The acceleration of the center of mass is g, downward.
E) None of the above statements are true.

7. The center of mass of a system of particles has a constant velocity if:

A) the forces exerted by the particles on each other sum to zero
B) the external forces acting on particles of the system sum to zero
C) the velocity of the center of mass is initially zero
D) the particles are distributed symmetrically around the center of mass
E) the center of mass is at the geometric center of the system

8. At the same instant that a 0.50-kg ball is dropped from 25 m above Earth, a second ball, with a mass of 0.25 kg, is thrown straight upward from Earth's surface with an initial speed of 15 m/s. They move along nearby lines and pass without colliding. At the end of 2.0 s the velocity of the center of mass of the two-ball system is:

A) 11 m/s, down
B) 11 m/s, up
C) 15 m/s, down
D) 15 m/s, up
E) 20 m/s, down

9. Two 4.0-kg blocks are tied together with a compressed spring between them. They are thrown from the ground with an initial velocity of 35 m/s, 45º above the horizontal. At the highest point of the trajectory they become untied and spring apart. About how far below the highest point is the center of mass of the two-block system 2.0 s later, before either fragment has hit the ground?

A) 12 m
B) 20 m
C) 31 m
D) Can't tell because the velocities of the fragments are not given.
E) Can't tell because the coordinates of the highest point are not given.

10. Block A, with a mass of 4 kg, is moving with a speed of 2.0 m/s while block B, with a mass of 8 kg, is moving in the opposite direction with a speed of 3 m/s. The center of mass of the two block-system is moving with a velocity of:

A) 1.3 m/s in the same direction as A
B) 1.3 m/s in the same direction as B
C) 2.7 m/s in the same direction as A
D) 1.0 m/s in the same direction as B
E) 5.0 m/s in the same direction as A

11. The center of mass of a uniform disk of radius *R* is located:

A) on the rim
B) a distance $R/2$ from the center
C) a distance $R/3$ from the center
D) a distance $2R/3$ from the center
E) at the center

12. The center of mass of a system of particles remains at the same place if:

A) it is initially at rest and the external forces sum to zero
B) it is initially at rest and the internal forces sum to zero
C) the sum of the external forces is less than the maximum force of static friction
D) no friction acts internally
E) none of the above

13. Which one of the following statements is true?

A) the center of mass of an object must lie within the object
B) all the mass of an object is actually concentrated at its center of mass
C) the center of mass of an object cannot move if there is zero net force on the object
D) the center of mass of a cylinder must lie on its axis
E) none of the above

14. The center of mass of Earth's atmosphere is:

A) a little less than halfway between Earth's surface and the outer boundary of the atmosphere
B) near the surface of Earth
C) near the outer boundary of the atmosphere
D) near the center of Earth
E) none of the above

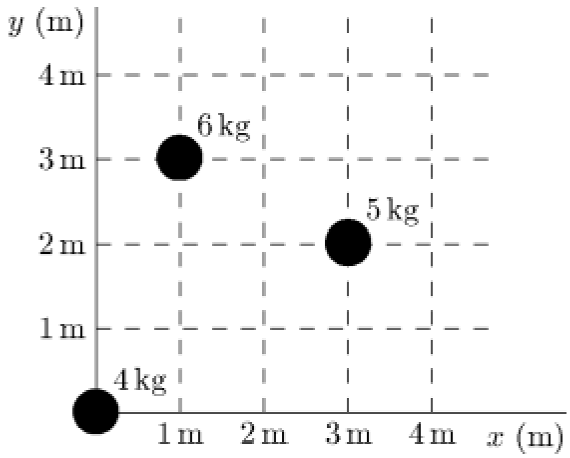
15. A system consists of two particles with masses of 2 kg and 4 kg, moving in opposite directions on the *x* axis. The velocity of the center of mass is $(3\,\text{m/s})\,\hat{\text{i}}$. The net momentum of the system:

A) is zero
B) is $(6\,\text{kg}\cdot\text{m/s})\,\hat{\text{i}}$
C) is $(9\,\text{kg}\cdot\text{m/s})\,\hat{\text{i}}$
D) is $(12\,\text{kg}\cdot\text{m/s})\,\hat{\text{i}}$
E) cannot be computed unless the velocities of the particles are given

16. Particle A has a mass of 1 kg and a speed of 3 m/s. Particle B has a mass of 2 kg. The speed of the center of mass of the two-particle system is 5 m/s. The greatest and least speed that particle B might have are:

A) 6 m/s and m/s
B) 3 m/s and 6 m/s
C) 0 and 3 m/s
D) 0 m/s and 9 m/s
E) 5 m/s and 6 m/s

17. The *x* and *y* coordinates of the center of mass of the three-particle system shown below are:



A) 0,0
B) 1.3 m, 1.7 m
C) 1.4 m, 1.9 m
D) 1.9 m, 2.5 m
E) 1.4 m, 2.5 m

18. The velocity of the center of mass of a two-particle system is $(2\,\text{m/s})\hat{\imath}$ and the net momentum of the system is $(8\,\text{kg}\cdot\text{m/s})\hat{\imath}$. If the mass of one of the particles 3 kg the mass of the other is:

A) zero
B) 1 kg
C) 2 kg
D) 3 kg
E) 4 kg

19. The center of mass of the system consisting of Earth, the Sun, and the planet Mars is:

A) closer to Earth than to either of the other bodies
B) closer to the Sun than to either of the other bodies
C) closer to Mars than to either of the other bodies
D) at the geometric center of the triangle formed by the three bodies
E) at the center of the line joining Earth and Mars

20. Cart A, with a mass of 0.20 kg, travels on a horizontal air track at 3.0 m/s and hits cart B, which has a mass of 0.40 kg and is initially traveling away from A at 2.0 m/s. After the collision the center of mass of the two cart system has a speed of:

A) zero
B) 0.33 m/s
C) 2.3 m/s
D) 2.5 m/s
E) 5.0 m/s

Answer Key

1. E
2. D
3. A
4. B
5. D
6. E
7. B
8. C
9. B
10. B
11. E
12. A
13. E
14. D
15. D
16. A
17. C
18. B
19. B
20. B

Name: ___________________________ Date: _____________

1. Vectors $\vec{a}$ and $\vec{b}$ each have magnitude L. When drawn with their tails at the same point, the angle between them is 30º. The value of $\vec{a}\cdot\vec{b}$ is:

A) zero
B) L^2
C) $\sqrt{3}L^2/2$
D) $2L^2$
E) none of these

2. A watt · second is a unit of:

A) force
B) power
C) displacement
D) speed
E) energy

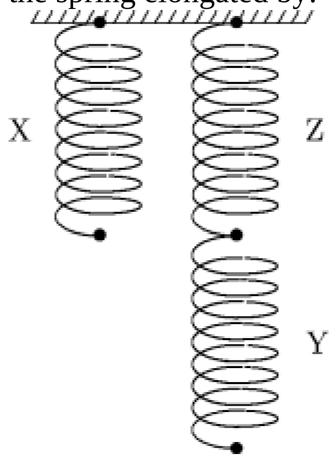
3. A 0.50-kg object moves on a horizontal frictionless circular track with a radius of 2.5 m. An external force of 3.0 N, always tangent to the track, causes the object to speed up as it goes around. If it starts from rest, then at the end of one revolution the radial component of the force of the track on it is:

A) 19 N
B) 38 N
C) 47 N
D) 75 N
E) 96 N

4. A 0.50-kg object moves in a horizontal circular track with a radius of 2.5 m. An external force of 3.0 N, always tangent to the track, causes the object to speed up as it goes around. The work done by the external force as the mass makes one revolution is:

A) 24 J
B) 47 J
C) 59 J
D) 94 J
E) 120 J

5. Three identical ideal springs (X,Y,Z) are arranged as shown. When a 4.0-kg block is hung on X, the block remains at rest when it is released with the spring elongated by 3.0 cm. When a 6.0-kg block is hung on Y, the block remains at rest when it is released with the spring elongated by:



A) 2.0 cm
B) 4.0 cm
C) 4.5 cm
D) 6.0 cm
E) 9.0 cm

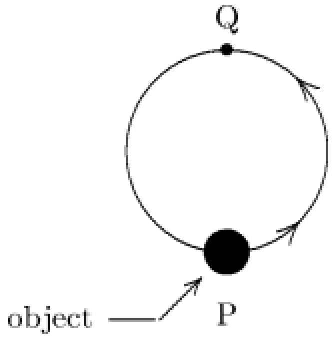
6. In raising an object to a given height by means of an inclined plane, as compared with raising the object vertically, there is a reduction in:

A) work required
B) distance pushed
C) friction
D) force required
E) value of the acceleration due to gravity

7. A watt is:

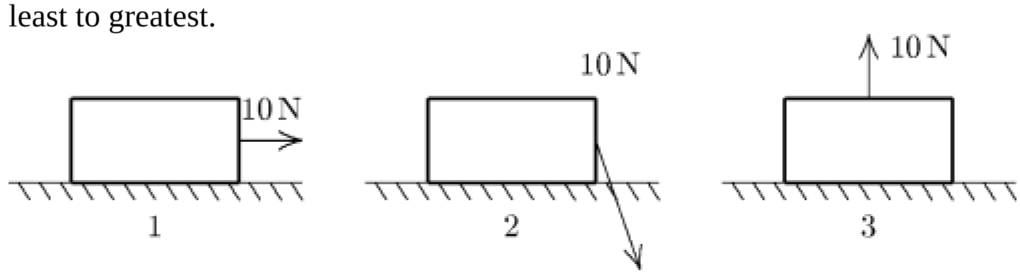
A) a $kg \cdot m/s^3$
B) a $kg \cdot m^2/s$
C) a $kg \cdot m^2/s^3$
D) a $kg \cdot m/s$
E) a $kg \cdot m^2/s^2$

8. A man moves the 10-g object shown in a vertical plane from position P to position Q along a circular track of radius 20 m. The process takes 0.75 min. The work done by the man is about:



A) 1 J
B) 2 J
C) 4 J
D) 6 J
E) 12 J

9. A crate moves 10 m to the right on a horizontal surface as a woman pulls on it with a 10-N force. Rank the situations shown below according to the work done by her force, least to greatest.



A) 1, 2, 3
B) 2, 1, 3
C) 2, 3, 1
D) 1, 3, 2
E) 3, 2, 1

10. A sledge (including load) weighs 5000 N. It is pulled on level snow by a dog team exerting a horizontal force on it. The coefficient of kinetic friction between sledge and snow is 0.05. How much work is done by the dog team pulling the sledge 1000 m at constant speed?

A) 2.5×10^4 J
B) 2.5×10^5 J
C) 5.0×10^5 J
D) 2.5×10^6 J
E) 5.0×10^6 J

11. Two bodies, A and B, have equal kinetic energies. The mass of A is nine times that of B. The ratio of the translational momentum of A to that of B is:

A) 1:9
B) 1:3
C) 1:1
D) 3:1
E) 9:1

12. A boy holds a 40-N weight at arm's length for 10 s. His arm is 1.5 m above the ground. The work done by the force of the boy on the weight while he is holding it is:

A) 0
B) 6.1 J
C) 40 J
D) 60 J
E) 90 J

13. A particle moves 5 m in the positive *x* direction while being acted upon by a constant force $\vec{F} = (4\,\mathrm{N})\hat{\mathrm{i}} + (2\,\mathrm{N})\hat{\mathrm{j}} - (4\,\mathrm{N})\hat{\mathrm{k}}$. The work done on the particle by this force is:

A) 20 J
B) 10 J
C) –20 J
D) 30 J
E) impossible to calculate without knowing other forces

14. The weight of an object on the moon is one-sixth of its weight on Earth. The ratio of the kinetic energy of a body on Earth moving with speed V to that of the same body moving with the same speed on the Moon is:

A) 6:1
B) 36:1
C) 1:1
D) 1:6
E) 1:36

15. An ideal spring is hung vertically from the ceiling. When a 2.0-kg block hangs at rest from it the spring is extended 6.0 cm from its relaxed length. A upward external force is then applied to the block to move it upward a distance of 16 cm. While the block is moving upward the work done by the spring is:

A) –1.0 J
B) –0.52 J
C) –0.26 J
D) 0.52 J
E) 1.0 J

16. A Boston Red Sox baseball player catches a ball of mass m that is moving toward him with speed v. While bringing the ball to rest, his hand moves back a distance d. Assuming constant deceleration, the horizontal force exerted on the ball by his hand is:

A) mv/d
B) mvd
C) mv^2/d
D) $2mv/d$
E) $mv^2/(2d)$

17. An ideal spring is hung vertically from the ceiling. When a 2.0-kg mass hangs at rest from it the spring is extended 6.0 cm from its relaxed length. A downward external force is now applied to the mass to extend the spring an additional 10 cm. While the spring is being extended by the force, the work done by the spring is:

A) –3.6 J
B) –3.3 J
C) -3.4×10^{-5} J
D) 3.3 J
E) 3.6 J

18. The work done by gravity during the descent of a projectile:

A) is positive
B) is negative
C) is zero
D) depends for its sign on the direction of the *y* axis
E) depends for its sign on the direction of both the *x* and *y* axes

19. A 1-kg block is lifted vertically 1 m by a boy. The work done by the boy is about:

A) 1 ft · lb
B) 1 J
C) 10 J
D) 0.1 J
E) zero

20. The amount of work required to stop a moving object is equal to:

A) the initial speed of the object
B) the initial kinetic energy of the object
C) the mass of the object times its acceleration
D) the mass of the object times its initial speed
E) the square of the initial speed of the object

Answer Key

1. D
2. E
3. B
4. B
5. E
6. D
7. C
8. C
9. E
10. B
11. D
12. A
13. A
14. C
15. A
16. E
17. A
18. A
19. C
20. B

Name: ___________________________ Date: _____________

1. An inelastic collision is one in which:

A) momentum is not conserved but kinetic energy is conserved
B) total mass is not conserved but momentum is conserved
C) neither kinetic energy nor momentum is conserved
D) momentum is conserved but kinetic energy is not conserved
E) the total impulse is equal to the change in kinetic energy

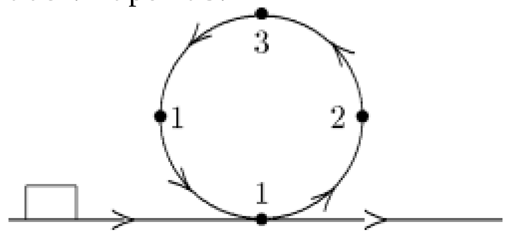
2. Whenever an object strikes a stationary object of equal mass:

A) the two objects cannot stick together
B) the collision must be elastic
C) the first object must stop
D) momentum is not necessarily conserved
E) none of the above

3. Objects A and B interact with each other via both conservative and nonconservative forces. Let K_A and K_B be the kinetic energies, U be the potential energy, and E^{thermal} be the thermal energy. If no external agent does work on the objects then:

A) $K_A + U$ is conserved
B) $K_A + U + E^{\text{thermal}}$ is conserved
C) $K_A + K_B + E^{\text{thermal}}$ is conserved
D) $K_A + K_B + U$ is conserved
E) $K_A + K_B + U + E^{\text{thermal}}$ is conserved

4. A rectangular block is moving along a frictionless path when it encounters the circular loop as shown. The block passes points 1, 2, 3, 4, 1 before returning to the horizontal track. At point 3:

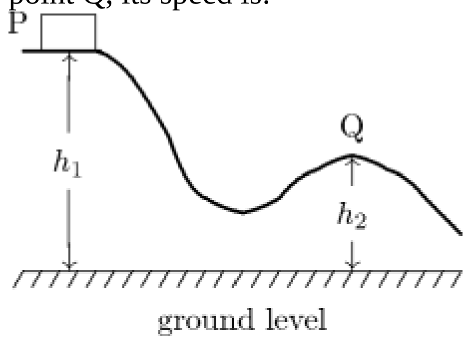


A) its mechanical energy is a minimum
B) the forces on it sum to zero
C) it is not accelerating
D) its speed is a minimum
E) it experiences a net upward force

5. A 0.75-kg block slides on a rough horizontal table top. Just before it hits a horizontal ideal spring its speed is 3.5 m/s. It compresses the spring 5.7 cm before coming to rest. If the spring constant is 1200 N/m, the thermal energy of the block and the table top must have:

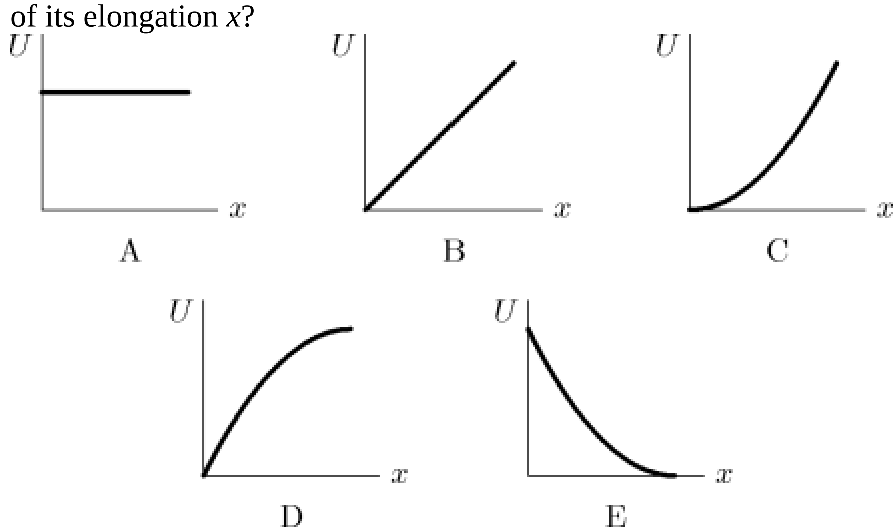
A) not changed
B) decreased by 1.9 J
C) decreased by 2.6 J
D) increased by 1.9 J
E) increased by 2.6 J

6. A block is released from rest at point P and slides along the frictionless track shown. At point Q, its speed is:



A) $2g\sqrt{h_1 - h_2}$
B) $2g(h_1 - h_2)$
C) $(h_1 - h_2)/2g$
D) $\sqrt{2g(h_1 - h_2)}$
E) $(h_1 - h_2)^2/2g$

7. Which of the five graphs correctly shows the potential energy of a spring as a function of its elongation x?



A) A
B) B
C) C
D) D
E) E

8. A 25-g ball is released from rest 80 m above the surface of Earth. During the fall the total internal energy of the ball and air increases by 15 J. Just before it hits the surface its speed is

A) 19 m/s
B) 36 m/s
C) 40 m/s
D) 45 m/s
E) 53 m/s

9. A projectile of mass 0.50 kg is fired with an initial speed of 10 m/s at an angle of 60° above the horizontal. The potential energy (relative to that at ground level) of the projectile at its highest point is:

A) 25 J
B) 18.75 J
C) 12.5 J
D) 6.25 J
E) none of these

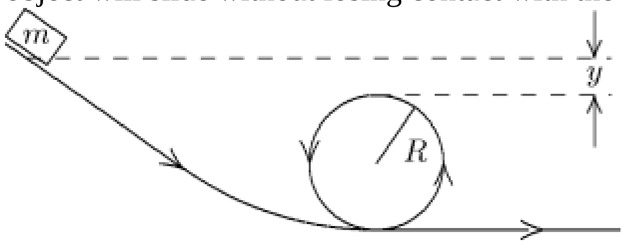
10. The sum of the kinetic and potential energies of a system of objects is conserved:

A) only when no external force acts on the objects
B) only when the objects move along closed paths
C) only when the work done by the resultant external force is zero
D) always
E) none of the above

11. Two particles interact by conservative forces. In addition, an external force acts on each particle. They complete round trips, ending at the points where they started. Which of the following must have the same values at the beginning and end of this trip?

A) the total kinetic energy of the two-particle system
B) the potential energy of the two-particle system
C) the mechanical energy of the two-particle system
D) the total linear momentum of the two-particle system
E) none of the above

12. A small object of mass *m* starts from rest at the position shown and slides along the frictionless loop-the-loop track of radius *R*. What is the smallest value of *y* such that the object will slide without losing contact with the track?

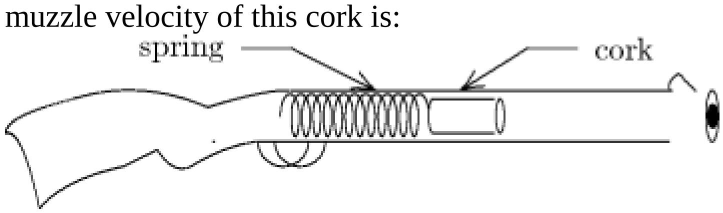


A) *R*/4
B) *R*/2
C) *R*
D) 2*R*
E) zero

13. A very massive object traveling at 10 m/s strikes a very light object, initially at rest, and the light object moves off in the direction of travel of the heavy object. If the collision is elastic, the speed of the lighter object is:

A) 5.0 m/s
B) 10 m/s
C) 15 m/s
D) 20 m/s
E) Can't tell from the information given.

14. A toy cork gun contains a spring whose spring constant is 10.0 N/m. The spring is compressed 5.00 cm and then used to propel a 6.00-g cork. The cork, however, sticks to the spring for 1.00 cm beyond its unstretched length before separation occurs. The muzzle velocity of this cork is:



A) 1.02 m/s
B) 1.41 m/s
C) 2.00 m/s
D) 2.04 m/s
E) 4.00 m/s

15. Blocks A and B are moving toward each other along the *x* axis. A has a mass of 2.0 kg and a velocity of $(50\,\text{m/s})\,\hat{\text{i}}$, while B has a mass of 4.0 kg and a velocity of $-(25\,\text{m/s})\,\hat{\text{i}}$. They suffer an elastic collision and move off along the *x* axis. The kinetic energy transferred from A to B during the collision is:

A) 0
B) 2500 J
C) 5000 J
D) 7500 J
E) 10000 J

16. A 5-kg projectile is fired over level ground with a velocity of 200 m/s at an angle of 25° above the horizontal. Just before it hits the ground its speed is 150 m/s. Over the entire trip the change in the thermal energy of the projectile and air is:

A) + 19,000 J
B) –19,000 J
C) + 44,000 J
D) – 44,000 J
E) 0

17. Two objects interact with each other and with no other objects. Initially object A has a speed of 5 m/s and object B has a speed of 10 m/s. In the course of their motion they return to their initial positions. Then A has a speed of 4 m/s and B has a speed of 7 m/s. We can conclude:

A) the potential energy changed from the beginning to the end of the trip
B) mechanical energy was increased by nonconservative forces
C) mechanical energy was decreased by nonconservative forces
D) mechanical energy was increased by conservative forces
E) mechanical energy was decreased by conservative forces

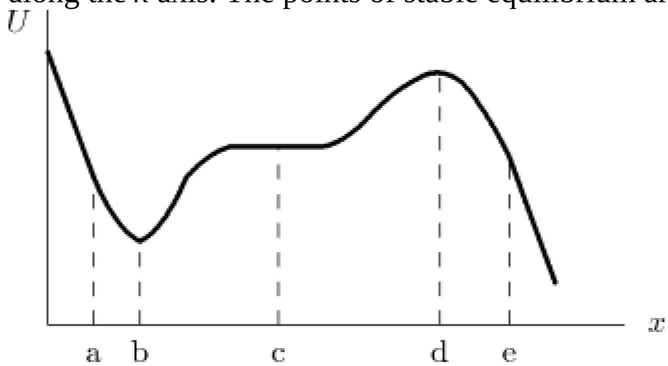
18. A 0.50-kg block attached to an ideal spring with a spring constant of 80 N/m oscillates on a horizontal frictionless surface. When the spring is 4.0 cm longer than its equilibrium length, the speed of the block is 0.50 m/s. The greatest speed of the block is:

A) 0.23 m/s
B) 0.32 m/s
C) 0.55 m/s
D) 0.71 m/s
E) 0.93 m/s

19. Only if a force acting is conservative is:

A) its work is zero when the particle moves exactly once around any closed path
B) its work equals the change in the kinetic energy of the particle
C) it obeys Newton's second law
D) it obeys Newton's third law
E) it is not a frictional force

20. The diagram shows a plot of the potential energy as a function of *x* for a particle moving along the *x* axis. The points of stable equilibrium are:

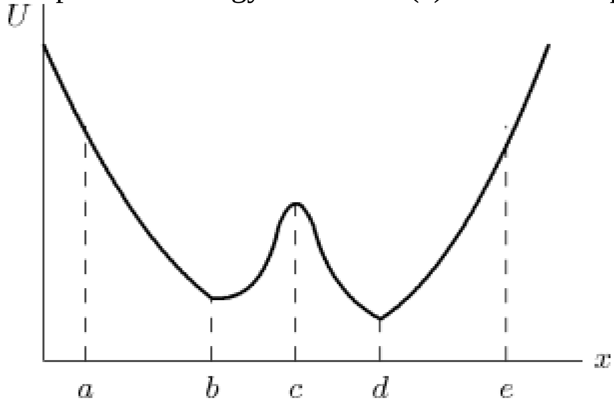


A) only a
B) only b
C) only c
D) only d
E) b and d

21. A 700-N man jumps out of a window into a fire net 10 m below. The net stretches 2 m before bringing the man to rest and tossing him back into the air. The maximum potential energy of the net, compared to its unstretched potential energy, is:

A) 300 J
B) 710 J
C) 850 J
D) 7000 J
E) 8400 J

22. A particle is released from rest at the point $x = a$ and moves along the x axis subject to the potential energy function $U(x)$ shown. The particle:



A) moves to $x = e$, stops, and remains at rest
B) moves to $x = e$, then moves to the left
C) moves to infinity at varying speed
D) moves to $x = b$, where it remains at rest
E) moves to $x = e$ and then to $x = d$, where it remains at rest

23. Two objects, X and Y, are held at rest on a horizontal frictionless surface and a spring is compressed between them. The mass of X is 2/5 times the mass of Y. Immediately after the spring is released, X has a kinetic energy of 50 J and Y has a kinetic energy of:

A) 20 J
B) 8 J
C) 310 J
D) 125 J
E) 50 J

24. An elastic collision is one in which:

A) momentum is not conserved but kinetic energy is conserved
B) total mass is not conserved but momentum is conserved
C) kinetic energy and momentum are both conserved
D) momentum is conserved but kinetic energy is not conserved
E) the total impulse is equal to the change in kinetic energy

25. The wound spring of a clock possesses:

A) kinetic but no potential energy
B) potential but no kinetic energy
C) the same potential as kinetic energy
D) neither potential nor kinetic energy
E) both kinetic and potential energy but more kinetic than potential energy

Answer Key

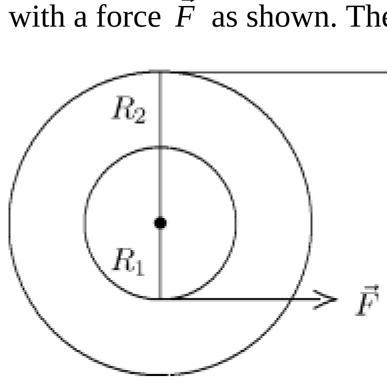
1. D
2. E
3. E
4. D
5. C
6. D
7. C
8. A
9. B
10. E
11. B
12. B
13. D
14. C
15. A
16. C
17. C
18. D
19. A
20. B
21. E
22. B
23. D
24. C
25. B

Name: ___________________________ Date: _____________

1. For a wheel spinning on an axis through its center, the ratio of the radial acceleration of a point on the rim to the radial acceleration of a point halfway between the center and the rim is:

A) 1
B) 2
C) 1/2
D) 4
E) 1/4

2. A small disk of radius R_1 is fastened coaxially to a larger disk of radius R_2. The combination is free to rotate on a fixed axle, which is perpendicular to a horizontal frictionless table top, as shown in the overhead view below. The rotational inertia of the combination is I. A string is wrapped around the larger disk and attached to a block of mass m, on the table. Another string is wrapped around the smaller disk and is pulled with a force $\vec{F}$ as shown. The tension in the string pulling the block is:

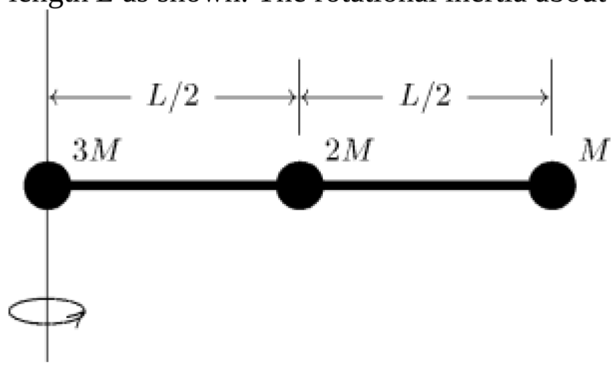


A) R_1F/R_2
B) $mR_1R_2F/(I-mR_2^2)$
C) $mR_1R_2F/(I + mR_2^2)$
D) $mR_1R_2F/(I-mR_1R_2)$
E) $mR_1R_2F/(I + mR_1R_2)$

3. A disk with a rotational inertia of 5.0 kg · m^2 and a radius of 0.25 m rotates on a frictionless fixed axis perpendicular to the disk and through its center. A force of 8.0 N is applied along the axis. The rotational acceleration of the disk is:

A) 0
B) 0.40 rad/s^2
C) 0.60 rad/s^2
D) 1.0 rad/s^2
E) 2.5 rad/s^2

4. Three identical balls, with masses of M, $2M$, and $3M$, are fastened to a massless rod of length L as shown. The rotational inertia about the left end of the rod is:



A) $ML^2/2$
B) ML^2
C) $3ML^2/2$
D) $6ML^2$
E) $3ML^2/4$

5. A wheel starts from rest and has a rotational acceleration of 4.0 rad/s^2. When it has made 10 rev its rotational velocity is:

A) 16 rad/s
B) 22 rad/s
C) 32 rad/s
D) 250 rad/s
E) 500 rad/s

6. A wheel starts from rest and has a rotational acceleration of 4.0 rad/s^2. The time it takes to make 10 rev is:

A) 0.50 s
B) 0.71 s
C) 2.2 s
D) 2.8 s
E) 5.6 s

7. A wheel initially has a rotational velocity of 18 rad/s but it is slowing at a rate of 2.0 rad/s^2. By the time it stops it will have turned through:

A) 81 rad
B) 160 rad
C) 245 rad
D) 330 rad
E) 410 rad

8. The rotational inertia of a solid uniform sphere about a diameter is $(2/5)MR^2$, where M is its mass and R is its radius. If the sphere is pivoted about an axis that is tangent to its surface, its rotational inertia is:

A) MR^2
B) $(2/5)MR^2$
C) $(3/5)MR^2$
D) $(5/2)MR^2$
E) $(7/5)MR^2$

9. A disk with a rotational inertia of 2.0 kg · m^2 and a radius of 0.40 m rotates on a frictionless fixed axis perpendicular to the disk faces and through its center. A force of 5.0 N is applied tangentially to the rim. The rotational acceleration of the disk is:

A) 0.40 rad/s^2
B) 0.60 rad/s^2
C) 1.0 rad/s^2
D) 2.5 rad/s^2
E) 10 rad/s^2

10. A disk with a rotational inertia of 5.0 kg · m^2 and a radius of 0.25 m rotates on a frictionless fixed axis perpendicular to the disk and through its center. A force of 8.0 N is applied tangentially to the rim. If the disk starts at rest, then after it has turned through half a revolution its rotational velocity is:

A) 0.57 rad/s
B) 0.64 rad/s
C) 0.80 rad/s
D) 1.6 rad/s
E) 3.2 rad/s

11. A radian is about:

A) 25º
B) 37º
C) 45º
D) 57º
E) 90º

12. The rotational velocity of a rotating wheel increases by 2 rev/s every minute. The rotational acceleration in rad/s^2 of this wheel is:

A) $4\pi^2$
B) 2π
C) 1/30
D) $\pi/15$
E) 4π

13. A flywheel of diameter 1.2 m has a constant rotational acceleration of 5.0 rad/s^2. The tangential acceleration of a point on its rim is:

A) 5.0 rad/s^2
B) 3.0 m/s^2
C) 5.0 m/s^2
D) 6.0 m/s^2
E) 12 m/s^2

14. A pulley with a radius of 3.0 cm and a rotational inertia of 4.5×10^{-3} kg · m^2 is suspended from the ceiling. A rope passes over it with a 2.0-kg block attached to one end and a 4.0-kg block attached to the other. The rope does not slip on the pulley. When the speed of the heavier block is 2.0 m/s the kinetic energy of the pulley is:

A) 0.15 J
B) 0.30 J
C) 1.0 J
D) 10 J
E) 20 J

15. When a thin uniform stick of mass M and length L is pivoted about its midpoint, its rotational inertia is $ML^2/12$. When pivoted about a parallel axis through one end, its rotational inertia is:

A) $ML^2/12$
B) $ML^2/6$
C) $ML^2/3$
D) $7ML^2/12$
E) $13ML^2/12$

16. A wheel initially has a rotational velocity of 36 rad/s but after 6.0 s its rotational velocity is 24 rad/s. If its rotational acceleration is constant its value is:

A) 2.0 rad/s^2
B) –2.0 rad/s^2
C) 3.0 rad/s^2
D) –3.0 rad/s^2
E) 6.0 rad/s^2

17. A wheel starts from rest and spins with a constant rotational acceleration. As time goes on the acceleration vector for a point on the rim:

A) decreases in magnitude and becomes more nearly tangent to the rim
B) decreases in magnitude and becomes more early radial
C) increases in magnitude and becomes more nearly tangent to the rim
D) increases in magnitude and becomes more nearly radial
E) increases in magnitude but retains the same angle with the tangent to the rim

18. A wheel starts from rest and has an rotational acceleration that is given by $\alpha(t) = (6\ \text{rad/s}^4)t^2$. The time it takes to make 10 rev is:

A) 2.8 s
B) 3.3 s
C) 4.0 s
D) 4.7 s
E) 5.3 s

19. Two wheels are identical but wheel B is spinning with twice the rotational speed of wheel A. The ratio of the magnitude of the radial acceleration of a point on the rim of B to the magnitude of the radial acceleration of a point on the rim of A is:

A) 1
B) 2
C) 1/2
D) 4
E) 1/4

20. The rotational inertia of a disk about its axis is 0.70 kg · m^2. When a 2.0-kg weight is added to its rim, 0.40 m from the axis, the rotational inertia becomes:

A) 0.38 kg · m^2
B) 0.54 kg · m^2
C) 0.70 kg · m^2
D) 0.86 kg · m^2
E) 1.0 kg · m^2

21. A disk is free to rotate on a fixed axis. A force of given magnitude F, in the plane of the disk, is to be applied. Of the following alternatives the greatest rotational acceleration is obtained if the force is:

A) applied tangentially halfway between the axis and the rim
B) applied tangentially at the rim
C) applied radially halfway between the axis and the rim
D) applied radially at the rim
E) applied at the rim but neither radially nor tangentially

22. A disk starts from rest and rotates about a fixed axis, subject to a constant net torque. The work done by the torque during the second revolution is ______ as the work done during the first revolution.

A) the same
B) twice as much
C) half as much
D) four times as much
E) one-fourth as much

23. One revolution is the same as:

A) 1 rad
B) 57 rad
C) $\pi/2$ rad
D) π rad
E) 2π rad

24. The magnitude of the acceleration of a point on a spinning wheel is increased by a factor of 4 if:

A) the magnitudes of the rotational velocity and the rotational acceleration are each increased by a factor of 4
B) the magnitude of the rotational velocity is increased by a factor of 4 and the magnitude of the rotational acceleration is not changed
C) the magnitudes of the rotational velocity and the rotational acceleration are each increased by a factor of 2
D) the magnitude of the rotational velocity is increased by a factor of 2 and the magnitude of the rotational acceleration is not changed
E) the rotational velocity is increased by a factor of 2 and the rotational acceleration is increased by a factor of 4

25. A certain wheel has a rotational inertia of 12 $kg \cdot m^2$. As it turns through 5.0 rev its rotational velocity increases from 5.0 rad/s to 6.0 rad/s. If the net torque is constant its value is:

A) 0.016 $N \cdot m$
B) 0.18 $N \cdot m$
C) 0.57 $N \cdot m$
D) 2.1 $N \cdot m$
E) 3.6 $N \cdot m$

Answer Key

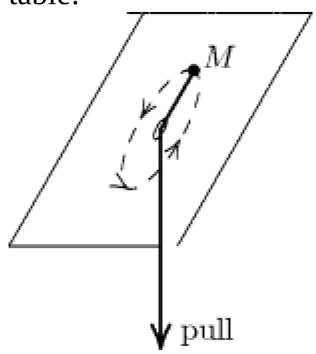
1. B
2. C
3. A
4. E
5. B
6. E
7. A
8. E
9. C
10. D
11. D
12. D
13. B
14. D
15. C
16. B
17. D
18. B
19. D
20. E
21. B
22. A
23. E
24. E
25. D

Name: ___________________________ Date: _____________

1. A sphere and a cylinder of equal mass and radius are simultaneously released from rest on the same inclined plane and roll without sliding down the incline. Then:

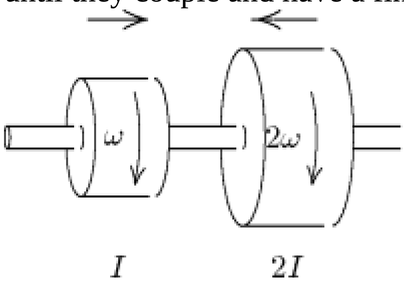
A) the sphere reaches the bottom first because it has the greater inertia
B) the cylinder reaches the bottom first because it picks up more rotational energy
C) the sphere reaches the bottom first because it picks up more rotational energy
D) they reach the bottom together
E) none of the above are true

2. A block with mass *M*, on the end of a string, moves in a circle on a horizontal frictionless table as shown. As the string is slowly pulled through a small hole in the table:



A) the rotational momentum of the block remains constant
B) the rotational momentum of the block decreases
C) the kinetic energy of the block remains constant
D) the kinetic energy of the block decreases
E) none of the above

3. Two disks are mounted on low-friction bearings on a common shaft. The first disc has rotational inertia I and is spinning with rotational speed ω. The second disc has rotational inertia $2I$ and is spinning in the same direction as the first disc with rotational speed 2ω as shown. The two disks are slowly forced toward each other along the shaft until they couple and have a final common rotational speed of:



A) $5\omega/3$
B) $\omega\sqrt{3}$
C) $\omega\sqrt{7/3}$
D) ω
E) 3ω

4. When the speed of a rear-drive car is increasing on a horizontal road the direction of the frictional force on the tires is:

A) forward for all tires
B) backward for all tires
C) forward for the front tires and backward for the rear tires
D) backward for the front tires and forward for the rear tires
E) zero

5. A forward force on the axle accelerates a rolling wheel on a horizontal surface. If the wheel does not slide the frictional force of the surface on the wheel is:

A) zero
B) in the forward direction
C) in the backward direction
D) in the upward direction
E) in the downward direction

6. A solid wheel with mass M, radius R, and rotational inertia $MR^2/2$, rolls without sliding on a horizontal surface. A horizontal force $\vec{F}$ is applied to the axle and the center of mass has an acceleration $\vec{a}$. The magnitudes of the applied force $\vec{F}$ and the frictional force $\vec{f}$ of the surface, respectively, are:

A) $F = Ma$, $f = 0$
B) $F = Ma$, $f = Ma/2$
C) $F = 2Ma$, $f = Ma$
D) $F = 2Ma$, $f = Ma/2$
E) $F = 3Ma/2$, $f = Ma/2$

7. A playground merry-go-round has a radius R and a rotational inertia I. When the merry-go-round is at rest, a child with mass m runs with speed v along a line tangent to the rim and jumps on. The rotational speed of the merry-go-round is then:

A) mv/I
B) v/R
C) mRv/I
D) $2mRv/I$
E) $mRv/(mR^2 + I)$

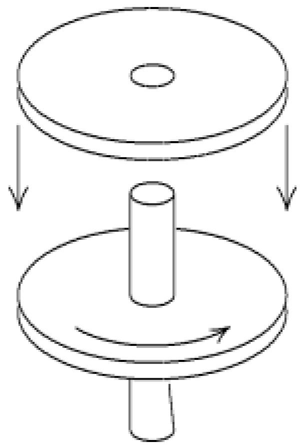
8. Two identical disks, with rotational inertia I ($=\frac{1}{2}MR^2$), roll without sliding across a horizontal floor with the same speed and then up inclines. Disk A rolls up its incline without sliding. On the other hand, disk B rolls up a frictionless incline. Otherwise the inclines are identical. Disk A reaches a height 12 cm above the floor before rolling down again. Disk B reaches a height above the floor of:

A) 24 cm
B) 18 cm
C) 12 cm
D) 8 cm
E) 6 cm

9. A phonograph record is dropped onto a freely spinning turntable. Then:

A) neither rotational momentum nor mechanical energy is conserved because of the frictional forces between record and turntable
B) the frictional force between record and turntable increases the total rotational momentum
C) the frictional force between record and turntable decreases the total rotational momentum
D) the total rotational momentum remains constant
E) the sum of the rotational momentum and rotational kinetic energy remains constant

10. A wheel with rotational inertia I, mounted on a vertical shaft with negligible rotational inertia, is rotating with rotational speed ω_0. A nonrotating wheel with rotational inertia $2I$ is suddenly dropped onto the same shaft as shown. The resultant combination of the two wheels and shaft will rotate at:



A) $\omega_0/2$
B) $2\omega_0$
C) $\omega_0/3$
D) $3\omega_0$
E) $\omega_0/4$

11. A uniform sphere of radius R rotates about a diameter with a rotational momentum of magnitude L. Under the action of internal forces the sphere collapses to a uniform sphere of radius $R/2$. The magnitude of its new rotational momentum is:

A) $L/4$
B) $L/2$
C) L
D) $2L$
E) $4L$

12. A 2.0-kg block travels around a 0.50-m radius circle with an rotational speed of 12 rad/s. The circle is parallel to the *xy* plane and is centered on the *z* axis, 0.75 m from the origin. The magnitude of its rotational momentum around the origin is:

A) 6.0 kg · m^2/s
B) 9.0 kg · m^2/s
C) 11 kg · m^2/s
D) 14 kg · m^2/s
E) 20 kg · m^2/s

13. As a 2.0-kg block travels around a 0.50-m radius circle it has a rotational speed of 12 rad/s. The circle is parallel to the *xy* plane and is centered on the *z* axis, a distance of 0.75 m from the origin. The *z* component of the rotational momentum around the origin is:

A) 6.0 kg · m^2/s
B) 9.0 kg · m^2/s
C) 11 kg · m^2/s
D) 14 kg · m^2/s
E) 20 kg · m^2/s

14. As a 2.0-kg block travels around a 0.50-m radius circle it has a rotational speed of 12 rad/s. The circle is parallel to the *xy* plane and is centered on the *z* axis, 0.75 m from the origin. The component in the *xy* plane of the rotational momentum around the origin has a magnitude of:

A) 0
B) 6.0 kg · m^2/s
C) 9.0 kg · m^2/s
D) 11 kg · m^2/s
E) 14 kg · m^2/s

15. A 2.0-kg stone is tied to a 0.50-m long string and swung around a circle at a constant rotational speed of 12 rad/s. The magnitude of the net torque on the stone about the center of the circle is:

A) 0
B) 6.0 N · m
C) 12 N · m
D) 72 N · m
E) 140 N · m

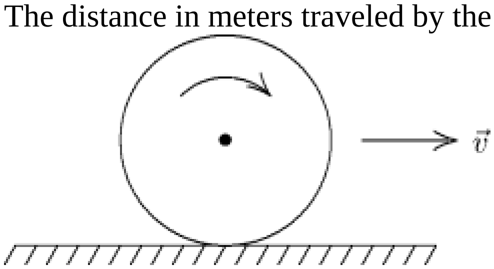
16. A 2.0-kg block starts from rest on the positive *x* axis 3.0 m from the origin and thereafter has a translational acceleration given by $\vec{a} = (4.0\,\mathrm{m/s^2})\hat{\mathrm{i}} - (3.0\,\mathrm{m/s^2})\hat{\mathrm{j}}$. At the end of 2.0 s its rotational momentum about the origin is:

A) 0
B) $(-36\,\mathrm{kg\cdot m^2/s})\hat{\mathrm{k}}$
C) $(+48\,\mathrm{kg\cdot m^2/s})\hat{\mathrm{k}}$
D) $(-96\,\mathrm{kg\cdot m^2/s})\hat{\mathrm{k}}$
E) $(+96\,\mathrm{kg\cdot m^2/s})\hat{\mathrm{k}}$

17. The newton · second is a unit of:

A) work
B) rotational momentum
C) power
D) translational momentum
E) none of these

18. A wheel of radius 0.5 m rolls without sliding on a horizontal surface as shown. Starting from rest at time $t_1 = 0$, the wheel moves with constant rotational acceleration 6 rad/s^2. The distance in meters traveled by the center of the wheel from time t_1 to time $t_2 = 3$ s is:



A) zero
B) 27
C) 13.5
D) 18
E) none of these

19. An ice skater with rotational inertia I_1 is spinning with rotational speed ω_1. She pulls her arms in, thereby increasing her rotational speed to $4\omega_1$. Her rotational inertia is then:

A) I_1
B) $I_1/2$
C) $2I_1$
D) $I_1/4$
E) $4I_1$

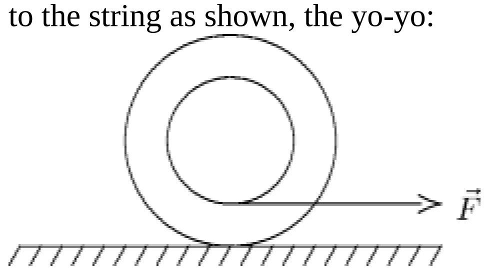
20. The fundamental dimensions of rotational momentum are:

A) mass · length · time^{-1}
B) mass · length^{-2} · time^{-2}
C) mass · length^{2} · time^{-1}
D) mass · length^{2} · time^{-2}
E) none of these

21. When a man on a frictionless rotating stool extends his arms horizontally, his rotational kinetic energy:

A) must increase
B) must decrease
C) must remain the same
D) may increase or decrease depending on his initial rotational speed
E) may increase or decrease depending on his rotational acceleration

22. A yo-yo, arranged as shown, rests on a frictionless surface. When a force $\vec{F}$ is applied to the string as shown, the yo-yo:



A) moves to the left and rotates counterclockwise
B) moves to the right and rotates counterclockwise
C) moves to the left and rotates clockwise
D) moves to the right and rotates clockwise
E) moves to the right and does not rotate

23. A man, with his arms at his sides, is spinning on a light frictionless turntable. When he extends his arms:

A) his rotational speed increases
B) his rotational speed remains the same
C) his rotational inertia decreases
D) his rotational kinetic energy increases
E) his rotational momentum remains the same

24. A 15-g paper clip is attached to the rim of a phonograph record with a radius of 30 cm, spinning at 3.5 rad/s. The magnitude of its rotational momentum is:

A) 1.4×10^{-3} kg · m^2/s
B) 4.7×10^{-3} kg · m^2/s
C) 1.6×10^{-2} kg · m^2/s
D) 3.2×10^{-1} kg · m^2/s
E) 1.1 kg · m^2/s

25. A man, holding a weight in each hand, stands at the center of a horizontal frictionless rotating turntable. The effect of the weights is to double the rotational inertia of the system. As he is rotating, the man opens his hands and drops the two weights. They fall outside the turntable. Then:

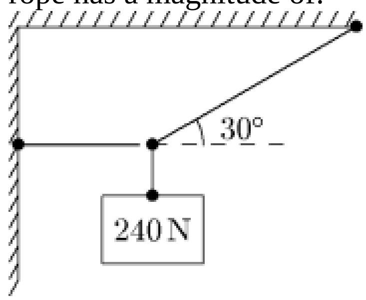
A) his rotational speed doubles
B) his rotational speed remains about the same
C) his rotational speed is halved
D) the direction of his rotational momentum vector changes
E) his rotational kinetic energy increases

Answer Key

1. E
2. A
3. A
4. D
5. D
6. E
7. E
8. D
9. D
10. C
11. C
12. C
13. A
14. C
15. A
16. B
17. D
18. C
19. D
20. C
21. B
22. B
23. E
24. B
25. B

Name: ___________________________ Date: _____________

1. A 240-N weight is hung from two ropes as shown. The tension force of the horizontal rope has a magnitude of:



A) 0
B) 656 N
C) 480 N
D) 416 N
E) 176 N

2. A cube with edges exactly 2 cm long is made of material with a bulk modulus of 3.5×10^9 N/m^2. When it is subjected to a pressure of 3.0×10^5 Pa its volume is:

A) 7.31 cm^3
B) 7.99931 cm^3
C) 8.00069 cm^3
D) 8.69 cm^3
E) none of these

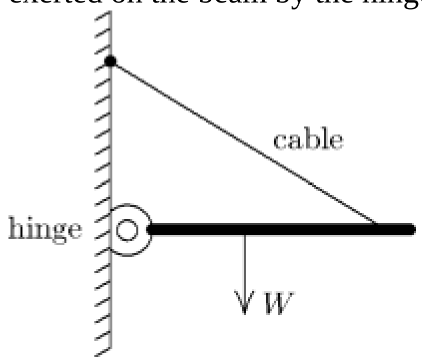
3. Young's modulus can be correctly given in:

A) N · m
B) N/m^2
C) N · m/s
D) N/m
E) joules

4. The bulk modulus is a proportionality constant that relates the pressure acting on an object to:

A) the shear
B) the fractional change in volume
C) the fractional change in length
D) Young's modulus
E) the spring constant

5. A horizontal beam of weight W is supported by a hinge and cable as shown. The force exerted on the beam by the hinge has a vertical component that must be:

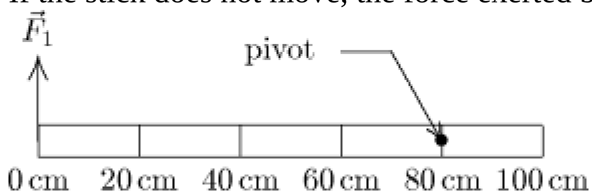


A) nonzero and up
B) nonzero and down
C) nonzero but not enough information given to know whether up or down
D) zero
E) equal to W

6. A force of 5000 N is applied outwardly to each end of a 5.0-m long rod with a radius of 34.0 cm and a Young's modulus of 125×10^8 N/m^2. The elongation of the rod is:

A) 0.0020 mm
B) 0.0040 mm
C) 0.14 mm
D) 0.55 mm
E) 1.42 mm

7. A meter stick on a horizontal frictionless table top is pivoted at the 80-cm mark. A force $\vec{F}_1$ is applied perpendicularly to the end of the stick at 0 cm, as shown. A second force $\vec{F}_2$ (not shown) is applied perpendicularly at the 60-cm mark. The forces are horizontal. If the stick does not move, the force exerted by the pivot on the stick:

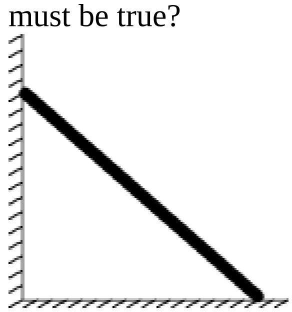


A) must be zero
B) must be in the same direction as $\vec{F}_1$ and have magnitude $|\vec{F}_2| - |\vec{F}_1|$
C) must be directed opposite to $\vec{F}_1$ and have magnitude $|\vec{F}_2| - |\vec{F}_1|$
D) must be in the same direction as $\vec{F}_1$ and have magnitude $|\vec{F}_2| + |\vec{F}_1|$
E) must be directed opposite to $\vec{F}_1$ and have magnitude $|\vec{F}_2| + |\vec{F}_1|$

8. Stress can be measured in:

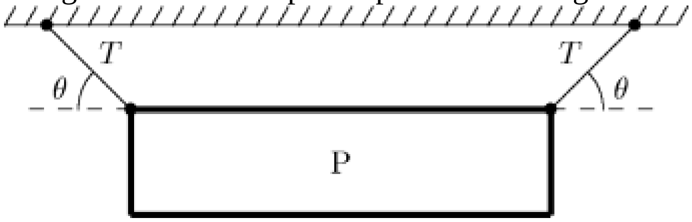
A) N/m^2
B) $N \cdot m^2$
C) N/m
D) $N \cdot m$
E) none of these (it is unitless)

9. A ladder leans against a wall. If the ladder is not to slip, which one of the following must be true?



A) The coefficient of friction between the ladder and the wall must not be zero
B) The coefficient of friction between the ladder and the floor must not be zero
C) Both A and B
D) Either A or B
E) Neither A nor B

10. A picture P of weight W is hung by two strings as shown. The tension force of each string is T. The total upward pull of the strings on the picture is:



A) $2W \cos \theta$
B) $T \sin \theta$
C) $T \cos \theta$
D) $2T \sin \theta$
E) $2T \cos \theta$

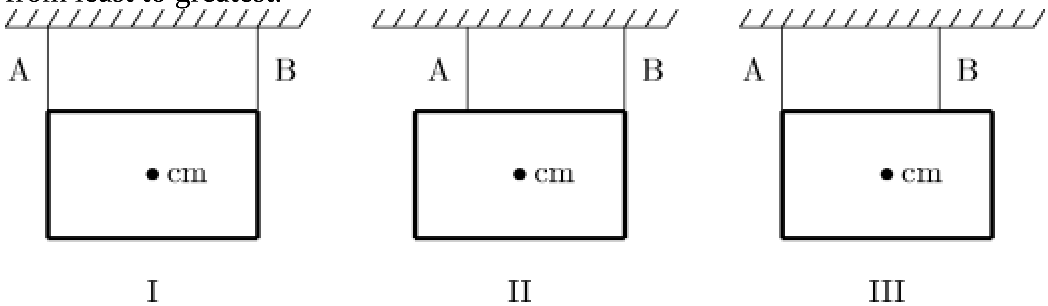
11. A cube with 2.0-cm sides is made of material with a bulk modulus of 4.7×10^5 N/m^2. When it is subjected to a pressure of 2.0×10^5 Pa the length of its any of its sides is:

A) 0.85 cm
B) 1.15 cm
C) 1.66 cm
D) 2.0 cm
E) none of these

12. A certain wire stretches 0.90 cm when certain outward forces are applied to each end. The same forces are applied to a wire of the same material but with three times the diameter and three times the length. The second wire stretches:

A) 0.01 cm
B) 0.30 cm
C) 0.90 cm
D) 2.7 cm
E) 8.1 cm

13. A picture is to be hung from the ceiling by means of two wires. Order the following arrangements of the wires according to the magnitude of the tension force of wire B, from least to greatest.

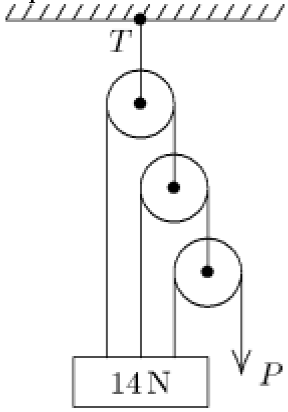


A) I, II, III
B) III, II, I
C) I and II tie, then III
D) II, I, III
E) all tie

14. The center of gravity coincides with the center of mass:

A) always
B) never
C) if the center of mass is at the geometrical center of the body
D) if the gravitational field strength uniform over the body
E) if the body has a uniform distribution of mass

15. The pull *P* is just sufficient to keep the 14-N block and the weightless pulleys in equilibrium as shown. The tension force *T* of the upper cable has a magnitude of:

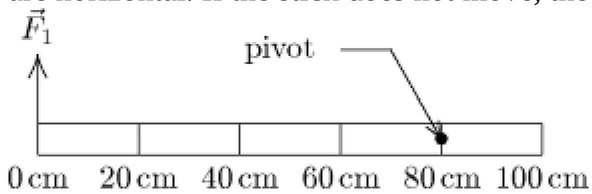


A) 14 N
B) 28 N
C) 16 N
D) 9.33 N
E) 18.7 N

16. For a body to be in equilibrium under the combined action of several forces:

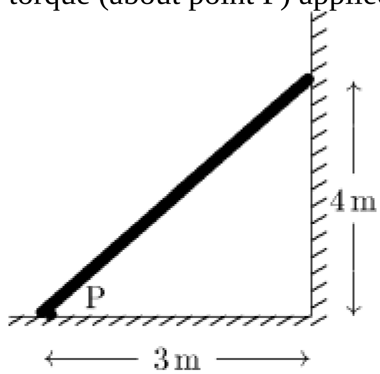
A) all the forces must be applied at the same point
B) all of the forces form pairs of equal and opposite forces
C) any two of these forces must be balanced by a third force
D) the sum of the torques about any point must equal zero
E) the lines of action of all the forces must pass through the center of gravity of the body

17. A meter stick on a horizontal frictionless table top is pivoted at the 80-cm mark. A force $\vec{F}_1$ is applied perpendicularly to the end of the stick at 0 cm, as shown. A second force $\vec{F}_2$ (not shown) is applied perpendicularly at the 100-cm end of the stick. The forces are horizontal. If the stick does not move, the force exerted by the pivot on the stick:



A) must be zero
B) must be in the same direction as $\vec{F}_1$ and have magnitude $|\vec{F}_2|-|\vec{F}_1|$
C) must be directed opposite to $\vec{F}_1$ and have magnitude $|\vec{F}_2|-|\vec{F}_1|$
D) must be in the same direction as $\vec{F}_1$ and have magnitude $|\vec{F}_2|+|\vec{F}_1|$
E) must be directed opposite to $\vec{F}_1$ and have magnitude $|\vec{F}_2|+|\vec{F}_1|$

18. An 80-N uniform plank leans against a frictionless wall as shown. The magnitude of the torque (about point P) applied to the plank by the wall is:

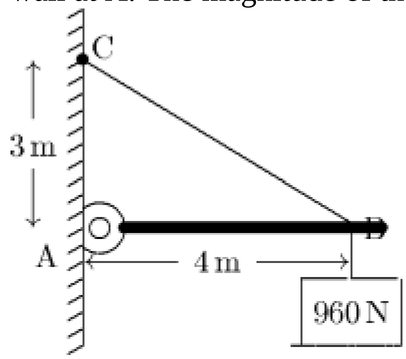


A) 40 N · m
B) 60 N · m
C) 120 N · m
D) 160 N · m
E) 240 N · m

19. Two supports, made of the same material and initially of equal length, are 2.0 m apart. A stiff board with a length of 4.0 m and a mass of 10 kg is placed on the supports, with one support at the left end and the other at the midpoint. A block is placed on the board a distance of 0.50 m from the left end. As a result the board is horizontal. The mass of the block is:

A) zero
B) 2.3 kg
C) 6.6 kg
D) 10 kg
E) 20 kg

20. A 960-N block is suspended as shown. The beam AB is weightless and is hinged to the wall at A. The magnitude of the tension force of the cable BC is:



A) 720 N
B) 1200 N
C) 1280 N
D) 1600 N
E) none of these

Answer Key

1. D
2. B
3. B
4. B
5. A
6. D
7. B
8. A
9. B
10. D
11. C
12. B
13. D
14. D
15. C
16. D
17. E
18. C
19. E
20. D

Name: ___________________________ Date: _____________

1. An artificial satellite of Earth releases a bomb. Neglecting air resistance, the bomb will:

A) strike Earth under the satellite at the instant of release
B) strike Earth under the satellite at the instant of impact
C) strike Earth ahead of the satellite at the instant of impact
D) strike Earth behind the satellite at the instant of impact
E) never strike Earth

2. A spherical shell has inner radius R_1, outer radius R_2, and mass M, distributed uniformly throughout the shell. The magnitude of the gravitational force exerted on the shell by a point mass particle of m, located a distance d from the center, inside the inner radius, is:

A) 0
B) GMm/R_1^2
C) GMm/d^2
D) $GMm/(R_2^2 - d^2)$
E) $GMm/(R_1 - d)^2$

3. The mass of a hypothetical planet is 1/100 that of Earth and its radius is 1/4 that of Earth. If a person weighs 600 N on Earth, what would he weigh on this planet?

A) 24 N
B) 48 N
C) 96 N
D) 192 N
E) 600 N

4. To measure the mass of a planet with the same radius as Earth, an astronaut drops an object from rest (relative to the planet) from an altitude of one radius above the surface. When the object hits its speed is 4 times what it would be if the same experiment were carried out for Earth. In units of Earth masses, the mass of the planet is:

A) 2
B) 4
C) 8
D) 16
E) 32

5. A spherical shell has inner radius R_1, outer radius R_2, and mass M, distributed uniformly throughout the shell. The magnitude of the gravitational force exerted on the shell by a point particle of mass m located a distance d from the center, outside the inner radius and inside the outer radius, is:

A) 0
B) GMm/d^2
C) $GMm/(R_2^3 – d^3)$
D) $GMm(d^3 – R_1^3)/d^2(R_2^3 – R_1^3)$
E) $GMm/(d^3 – R_1^3)$

6. Neglecting air resistance, a 1.0-kg projectile has an escape velocity of about 11 km/s at the surface of Earth. The corresponding escape velocity for a 2.0 kg projectile is:

A) 3.5 km/s
B) 5.5 km/s
C) 7.1 km/s
D) 10 km/s
E) 11 km/s

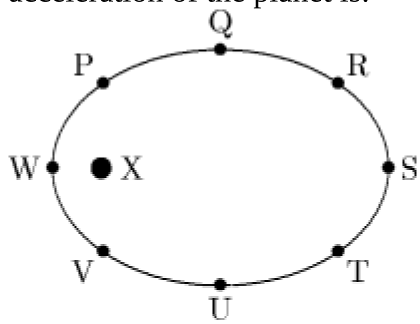
7. The gravitational constant G has the derived units:

A) N · m
B) N · m/kg
C) N · kg/m
D) N · m^2/kg^2
E) N · kg^2/m^2

8. An object is raised from the surface of Earth to a height of two Earth radii above Earth. Then:

A) its mass increases and its weight remains constant
B) both its mass and weight remain constant
C) its mass remains constant and its weight decreases
D) both its mass and its weight decrease
E) its mass remains constant and its weight increases

9. A planet travels in an elliptical orbit about a star X as shown. The magnitude of the acceleration of the planet is:



A) greatest at point Q
B) greatest at point S
C) greatest at point U
D) greatest at point W
E) the same at all points

10. The magnitude of the acceleration of a planet in orbit around the Sun is proportional to:

A) the mass of the planet
B) the mass of the Sun
C) the distance between the planet and the Sun
D) the reciprocal of the distance between the planet and the Sun
E) the product of the mass of the planet and the mass of the Sun

11. A rocket ship is coasting toward a planet. Its captain wishes to know the value of *g* at the surface of the planet. This may be inferred by:

A) measuring the apparent weight of one of the crew
B) measuring the apparent weight of an object of known mass in the ship
C) measuring the diameter of the planet
D) measuring the density of the planet
E) observing the ship's acceleration and correcting for the distance from the center of the planet.

12. If Earth were to rotate only 100 times per year about its axis:

A) airplanes flying W to E would make better time
B) we would fly off Earth's surface
C) our apparent weight would slightly increase
D) Earth's atmosphere would float into outer space
E) our apparent weight would slightly decrease

13. In the formula $F^{\text{grav}} = Gm_1m_2/r^2$, the quantity G:

A) depends on the local value of g
B) is used only when Earth is one of the two masses
C) is greatest at the surface of Earth
D) is a universal constant of nature
E) is related to the Sun in the same way that g is related to Earth

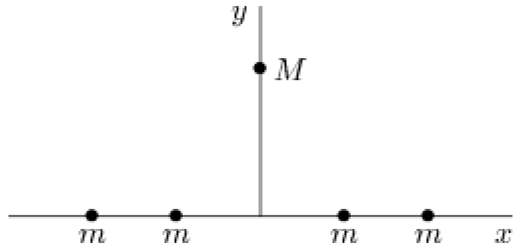
14. Of the following where would the weight of an object be the least?

A) 2000 miles above Earth's surface
B) At the north pole
C) At the equator
D) At the center of Earth
E) At the south pole

15. An object is dropped from an altitude of one Earth radius above Earth's surface. If M is the mass of Earth and R is its radius the speed of the object just before it hits Earth is given by:

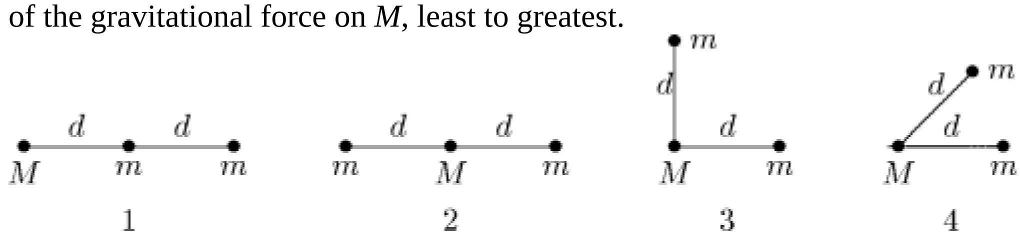
A) $\sqrt{GM/R}$
B) $\sqrt{GM/2R}$
C) $\sqrt{2GM/R}$
D) $\sqrt{GM/R^2}$
E) $\sqrt{GM/2R^2}$

16. Four particles, each with mass *m*, are arranged symmetrically about the origin on the *x* axis. A fifth particle, with mass *M*, is on the *y* axis. The direction of the gravitational force on *M* is:



A) ↑
B) ↓
C) ←
D) →
E) none of these directions

17. Three particles, two with mass *m* and one with mass *M*, might be arranged in any of the four configurations known below. Rank the configurations according to the magnitude of the gravitational force on *M*, least to greatest.



A) 1, 2, 3, 4
B) 2, 1, 3, 4
C) 2, 1, 4, 3
D) 2, 3, 4, 2
E) 2, 3, 2, 4

18. Let *M* denote the mass of Earth and let *R* denote its radius. The ratio g/G at Earth's surface is:

A) R^2/M
B) M/R^2
C) MR^2
D) M/R
E) R/M

19. Two particles, each of mass m, are a distance d apart. To bring a third particle, with mass $2m$, from far away to a resting point midway between the two particles the work done by an external agent is given by:

A) $4Gm^2/d$
B) $-4Gm^2/d$
C) $8Gm^2/d^2$
D) $-8Gm^2/d^2$
E) zero

20. The mass of an object:

A) is slightly different at different locations on Earth
B) is a vector
C) is independent of the acceleration due to gravity
D) is the same for all objects of the same size and shape
E) can be measured directly and accurately on a spring scale

21. Suppose you have a pendulum clock that keeps correct time on Earth (acceleration due to gravity = 9.8 m/s^2). Without changing the clock, you take it to the Moon (acceleration due to gravity = 1.6 m/s^2). For every hour interval (on Earth) the Moon clock will record:

A) (9.8/1.6) h
B) 1 h
C) $\sqrt{9.8/1.6}$ h
D) (1.6/9.8) h
E) $\sqrt{1.6/9.8}$ h

22. A spherical shell has inner radius R_1, outer radius R_2, and mass M, distributed uniformly throughout the shell. The magnitude of the gravitational force exerted on the shell by a point mass m, located a distance d from the center, outside the outer radius, is:

A) 0
B) GMm/R_1^2
C) GMm/d^2
D) $GMm/(R_2^2-d^2)$
E) $GMm/(R_1-d)^2$

23. Neglecting air resistance, the escape speed from a certain planet for an empty space vehicle is 1.12×10^4 m/s. What is the corresponding escape speed for the fully loaded vehicle, which has triple the mass of the empty one?

A) 3.73×10^3 m/s
B) 1.12×10^4 m/s
C) 3.36×10^4 m/s
D) 9.98×10^4 m/s
E) 1.40×10^{12} m/s

24. A spring scale, calibrated in newtons, is used to weigh sugar. If it were possible to weigh sugar at the following locations, where will the buyer get the most sugar to a newton?

A) At the north pole
B) At the equator
C) At the center of Earth
D) On the Moon
E) On Jupiter

25. The approximate value of g at an altitude above Earth equal to one Earth diameter is:

A) 9.8 N/kg
B) 4.9 N/kg
C) 2.5 N/kg
D) 1.9 N/kg
E) 1.1 N/kg

Answer Key

1. E
2. A
3. C
4. D
5. D
6. E
7. D
8. C
9. D
10. B
11. E
12. C
13. D
14. D
15. A
16. B
17. B
18. B
19. D
20. C
21. E
22. C
23. B
24. C
25. E

Name: ___________________________ Date: _____________

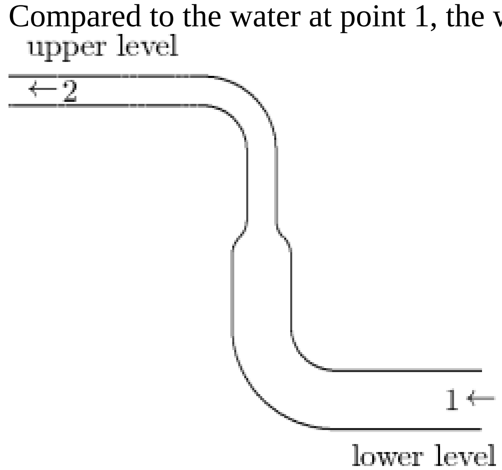
1. The principle of fluid pressure that is used in hydraulic brakes or lifts is that:

A) pressure is the same at all levels in a fluid
B) increases of pressure are transmitted equally to all parts of a fluid
C) the pressure at a point in a fluid is due to the weight of the fluid above it
D) increases of pressure can only be transmitted through fluids
E) the pressure at a given depth is proportional to the depth in the fluid

2. A fluid is undergoing "incompressible" flow. This means that:

A) the pressure at a given point cannot change with time
B) the velocity at a given point cannot change with time
C) the velocity must be the same everywhere
D) the pressure must be the same everywhere
E) the density cannot change with time or location

3. Water is pumped through the hose shown below, from a lower level to an upper level. Compared to the water at point 1, the water at point 2:



A) has greater speed and greater pressure
B) has greater speed and less pressure
C) has less speed and less pressure
D) has less speed and greater pressure
E) has greater speed and the same pressure

4. A closed hemispherical shell of radius R is filled with fluid at uniform pressure P. The net force of the fluid on the curved portion of the shell is given by:

A) $2\pi R^2 P$
B) $\pi R^2 P$
C) $4\pi R^2 P$
D) $(4/3)\pi R^2 P$
E) $(4/3)\pi R^3 P$

5. All fluids are:

A) gases
B) liquids
C) gases or liquids
D) non-metallic
E) transparent

6. Water flows from a 6.0-cm diameter pipe into an 8.0-cm diameter pipe. The speed in the 6.0-cm pipe is 5.0 m/s. The speed in the 8.0-cm pipe is:

A) 2.8 m/s
B) 3.7 m/s
C) 6.6 m/s
D) 8.8 m/s
E) 9.9 m/s

7. A large tank filled with water has two holes in the bottom, one with twice the radius of the other. In steady flow the speed of water leaving the larger hole is ______ the speed of the water leaving the smaller.

A) twice
B) four times
C) half
D) one-fourth
E) the same as

8. A lawn sprinkler is made of a 1.0-cm diameter garden hose with one end closed and 25 holes, each with a diameter of 0.050 cm, cut near the closed end. If water flows at 2.0 m/s in the hose, the speed of the water leaving a hole is:

A) 2.0 m/s
B) 32 m/s
C) 40 m/s
D) 600 m/s
E) 800 m/s

9. A rock, which weighs 1400 N in air, has an apparent weight of 900 N when submerged in fresh water (998 kg/m^3). The volume of the rock is:

A) 0.14 m^3
B) 0.60 m^3
C) 0.90 m^3
D) 5.1×10^{-2} m^3
E) 9.2×10^{-2} m^3

10. A person blows across the top of one arm of a U-tube partially filled with water. The water in that arm:

A) rises slightly
B) drops slightly
C) remains at the same height
D) rises if the blowing is soft but drops if it is hard
E) rises if the blowing is hard but drops if it is soft

11. Barometers and open-tube manometers are two instruments that are used to measure pressure.

A) Both measure gauge pressure
B) Both measure absolute pressure
C) Barometers measure gauge pressure and manometers measure absolute pressure
D) Barometers measure absolute pressure and manometers measure gauge pressure
E) Both measure an average of the absolute and gauge pressures

12. A block of ice at 0º C is floating on the surface of ice water in a beaker. The surface of the water just comes to the top of the beaker. When the ice melts the water level will:

A) rise and overflow will occur
B) remain the same
C) fall
D) depend on the initial ratio of water to ice
E) depend on the shape of the block of ice

13. One end of a cylindrical pipe has a radius of 1.5 cm. Water (density = 1.0×10^3 kg/m^3) streams steadily out at 7.0 m/s. The rate at which mass is leaving the pipe is:

A) 2.5 kg/s
B) 4.9 kg/s
C) 7.0 kg/s
D) 48 kg/s
E) 7.0×10^3 kg/s

14. Bernoulli's equation can be derived from the conservation of:

A) energy
B) mass
C) rotational momentum
D) volume
E) pressure

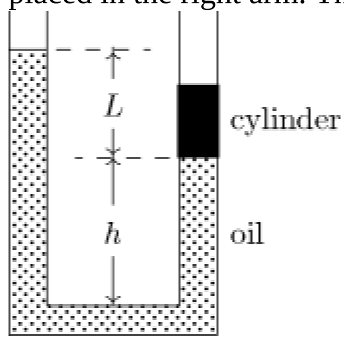
15. A student standardizes the concentration of a saltwater solution by slowly adding salt until an egg will just float. The procedure is based on the assumption that:

A) all eggs have the same volume
B) all eggs have the same weight
C) all eggs have the same density
D) all eggs have the same shape
E) the salt tends to neutralize the cholesterol in the egg

16. A non-viscous incompressible liquid is flowing through a horizontal pipe of constant cross section. Bernoulli's equation and the equation of continuity predict that the drop in pressure along the pipe:

A) is zero
B) depends on the length of the pipe
C) depends on the fluid velocity
D) depends on the cross-sectional area of the pipe
E) depends on the height of the pipe

17. The diagram shows a U-tube with cross-sectional area A and partially filled with oil of density ρ. A solid cylinder, which fits the tube tightly but can slide without friction, is placed in the right arm. The system is in equilibrium. The weight of the cylinder is:



A) $AL\rho g$
B) $L^3\rho g$
C) $A\rho(L + h)g$
D) $A\rho(L - h)g$
E) none of these

18. If P is a pressure and ρ is a density then P/ρ has units of:

A) m^2
B) m^2/s^2
C) N/m^2
D) kg/m^2
E) m^3/kg

19. Water (density = 1.0×10^3 kg/m^3) flows through a horizontal tapered pipe. At the wide end its speed is 4.0 m/s. The difference in pressure between the two ends is 4.5×10^3 Pa. The speed of the water at the narrow end is:

A) 2.6 m/s
B) 3.4 m/s
C) 4.0 m/s
D) 4.5 m/s
E) 5.0 m/s

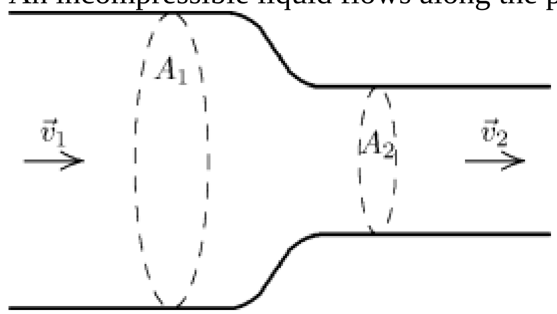
20. An object hangs from a spring balance. The balance indicates 30 N in air and 20 N when the object is submerged in water. What does the balance indicate when the object is submersed in a liquid with a density that is half that of water?

A) 20 N
B) 25 N
C) 30 N
D) 35 N
E) 40 N

21. Mercury is a convenient liquid to use in a barometer because:

A) it is a metal
B) it has a high boiling point
C) it expands little with temperature
D) it has a high density
E) it looks silvery

22. An incompressible liquid flows along the pipe as shown. The ratio of the speeds v_2/v_1 is:



A) A_1/A_2
B) A_2/A_1
C) $\sqrt{A_1/A_2}$
D) $\sqrt{A_2/A_1}$
E) v_1/v_2

23. Water is streaming downward from a faucet opening with an area of 3.0×10^{-5} m^2. It leaves the faucet with a speed of 5.0 m/s. The cross-sectional area of the stream 0.50 m below the faucet is:

A) 1.5×10^{-5} m^2
B) 2.0×10^{-5} m^2
C) 2.5×10^{-5} m^2
D) 3.0×10^{-5} m^2
E) 3.5×10^{-5} m^2

24. Water is pumped into one end of a long pipe at the rate of 40 L/min. It emerges at the other end at 24 L/min. A possible reason for this decrease in flow is:

A) the water is being pumped uphill
B) the water is being pumped downhill
C) the diameter of the pipe is not the same at the two ends
D) friction in the pipe
E) a leak in the pipe

25. Two balls have the same shape and size but one is denser than the other. If frictional forces are negligible when they are dropped in air, which has the greater acceleration?

A) The heavier ball
B) The lighter ball
C) They have the same acceleration
D) The heavier ball if atmospheric pressure is high, they lighter ball if it is low
E) The lighter ball if atmospheric pressure is high, the heavier ball if it is low

Answer Key

1. B
2. E
3. B
4. B
5. C
6. A
7. E
8. B
9. D
10. A
11. D
12. B
13. B
14. A
15. C
16. A
17. A
18. B
19. E
20. B
21. D
22. A
23. C
24. E
25. A

Name: ___________________________ Date: _____________

1. A simple pendulum consists of a small ball tied to a string and set in oscillation. As the pendulum swings the tension force of the string is:

A) constant
B) a sinusoidal function of time
C) the square of a sinusoidal function of time
D) the reciprocal of a sinusoidal function of time
E) none of the above

2. A block attached to a spring oscillates in simple harmonic motion along the *x* axis. The limits of its motion are *x* = 10 cm and *x* = 50 cm and it goes from one of these extremes to the other in 0.25 s. Its amplitude and frequency are:

A) 40 cm, 2 Hz
B) 20 cm, 4 Hz
C) 40 cm, 2 Hz
D) 25 cm, 4 Hz
E) 20 cm, 2 Hz

3. The table below gives the values of the spring constant *k*, damping constant *b*, and mass *m* for a particle in damped harmonic motion. Which of these takes the longest time for its mechanical energy to decrease to one-fourth of its initial value?

	k	b	m
A	k_0	b_0	m_0
B	$3k_0$	$2b_0$	$m_0 1$
C	$k_0/2$	$6b_0$	$2m_0$
D	$4k_0$	b_0	$2m_0$
E	k_0	b_0	$10m_0$

A) A
B) B
C) C
D) D
E) E

4. An oscillator is subjected to a damping force that is proportional to its velocity. A sinusoidal force is applied to it. After a long time:

A) its amplitude is an increasing function of time
B) its amplitude is a decreasing function of time
C) its amplitude is constant
D) its amplitude is a decreasing function of time only if the damping constant is large
E) its amplitude increases over some portions of a cycle and decreases over other portions

5. The displacement of an object oscillating on a spring is given by $x(t) = X \cos(\omega t + \phi_0)$. If the object is initially displaced in the negative x direction and given a negative initial velocity, then the phase constant ϕ_0 is between:

A) 0 and $\pi/2$ rad
B) $\pi/2$ and π rad
C) π and $3\pi/2$ rad
D) $3\pi/2$ and 2π rad
E) none of the above (ϕ_0 is exactly 0, $\pi/2$, π, or $3\pi/2$ rad)

6. A sinusoidal force with a given amplitude is applied to an oscillator. To maintain the largest amplitude oscillation the frequency of the applied force should be:

A) half the natural frequency of the oscillator
B) the same as the natural frequency of the oscillator
C) twice the natural frequency of the oscillator
D) unrelated to the natural frequency of the oscillator
E) determined from the maximum speed desired

7. It is impossible for two particles, each executing simple harmonic motion, to remain in phase with each other if they have different:

A) masses
B) periods
C) amplitudes
D) spring constants
E) kinetic energies

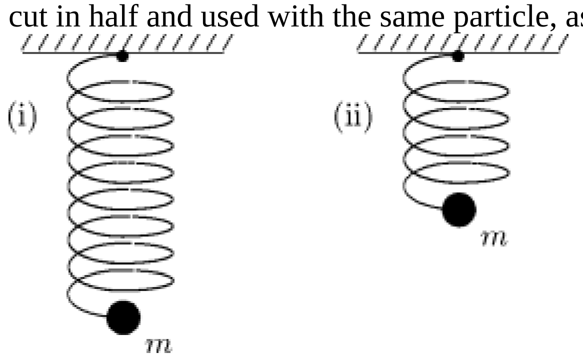
8. A block on a spring is subjected to a damping force that is proportional to its velocity and to an applied sinusoidal force. The energy dissipated by damping is supplied by:

A) the potential energy of the spring
B) the kinetic energy of the mass
C) gravity
D) friction
E) the applied force

9. In simple harmonic motion, the restoring force must be proportional to the:

A) amplitude
B) frequency
C) velocity
D) displacement
E) displacement squared

10. A simple harmonic oscillator consists of an particle of mass *m* and an ideal spring with spring constant *k*. The particle oscillates as shown in (i) with period *T*. If the spring is cut in half and used with the same particle, as shown in (ii), the period will be:



A) $2T$
B) $\sqrt{2}T$
C) $T/\sqrt{2}$
D) T
E) $T/2$

11. Let U be the potential energy (with the zero at zero displacement) and K be the kinetic energy of a simple harmonic oscillator. $\langle U \rangle$ and $\langle K \rangle$ are the average values over a cycle. Then:

A) $\langle K \rangle$ is greater than $\langle U \rangle$
B) $\langle K \rangle$ is less than $\langle U \rangle$
C) $\langle K \rangle$ is equal to $\langle U \rangle$
D) $K = 0$ when $U = 0$
E) $K + U = 0$

12. Two uniform spheres are pivoted on horizontal axes that are tangent to their surfaces. The one with the longer period of oscillation is the one with:

A) the larger mass
B) the smaller mass
C) the larger rotational inertia
D) the smaller rotational inertia
E) the larger radius

13. A mass-spring system is oscillating with amplitude X. The kinetic energy will equal the potential energy only when the displacement is:

A) zero
B) $\pm X/4$
C) $\pm X/\sqrt{2}$
D) $\pm X/2$
E) anywhere between $-X$ and $+X$

14. The amplitude of any oscillator can be doubled by:

A) doubling only the initial displacement
B) doubling only the initial speed
C) doubling the initial displacement and halving the initial speed
D) doubling the initial speed and halving the initial displacement
E) doubling both the initial displacement and the initial speed

15. A 0.25-kg block oscillates on the end of the spring with a spring constant of 200 N/m. If the oscillation is started by elongating the spring 0.15 m and giving the block a speed of 3.0 m/s, then the maximum speed of the block is:

A) 0.13 m/s
B) 0.18 m/s
C) 3.7 m/s
D) 5.2 m/s
E) 13 m/s

16. In simple harmonic motion:

A) the acceleration is greatest at the maximum displacement
B) the velocity is greatest at the maximum displacement
C) the period depends on the amplitude
D) the acceleration is constant
E) the acceleration is greatest at zero displacement

17. A particle is in simple harmonic motion along the x axis. The amplitude of the motion is X. At one point in its motion its kinetic energy is $K = 5$ J and its potential energy (measured with $U = 0$ at $x = 0$) is $U = 3$ J. When it is at $x = X$, the kinetic and potential energies are:

A) $K = 5$ J and $U = 3$ J
B) $K = 5$ J and $U = -3$ J
C) $K = 8$ J and $U = 0$
D) $K = 0$ and $U = 8$ J
E) $K = 0$ and $U = -8$ J

18. In simple harmonic motion, the magnitude of the acceleration is:

A) constant
B) proportional to the displacement
C) inversely proportional to the displacement
D) greatest when the velocity is greatest
E) never greater than g

19. An object on the end of a spring is set into oscillation by giving it an initial velocity while it is at its equilibrium position. In the first trial the initial velocity is v_0 and in the second it is $4v_0$. In the second trial:

A) the amplitude is half as great and the maximum acceleration is twice as great
B) the amplitude is twice as great and the maximum acceleration is half as great
C) both the amplitude and the maximum acceleration are twice as great
D) both the amplitude and the maximum acceleration are four times as great
E) the amplitude is four times as great and the maximum acceleration is twice as great

20. The amplitude and phase constant of an oscillator are determined by:

A) the frequency
B) the angular frequency
C) the initial displacement alone
D) the initial velocity alone
E) both the initial displacement and velocity

21. A 0.20-kg object attached to a spring whose spring constant is 500 N/m executes simple harmonic motion. If its maximum speed is 5.0 m/s, the amplitude of its oscillation is:

A) 0.0020 m
B) 0.10 m
C) 0.20 m
D) 25 m
E) 250 m

22. The amplitude of oscillation of a simple pendulum is increased from 1º to 4º. Its maximum acceleration changes by a factor of:

A) 1/4
B) 1/2
C) 2
D) 4
E) 16

23. A simple pendulum is suspended from the ceiling of an elevator. The elevator is accelerating upwards with acceleration a. The period of this pendulum, in terms of its length L, g, and a is:

A) $2\pi\sqrt{L/g}$
B) $2\pi\sqrt{L/(g+a)}$
C) $2\pi\sqrt{L/(g-a)}$
D) $2\pi\sqrt{L/a}$
E) $(1/2\pi)\sqrt{g/L}$

24. A certain spring elongates 9.0 mm when it is suspended vertically and a block of mass M is hung on it. The natural angular frequency of this block-spring system:

A) is 0.088 rad/s
B) is 33 rad/s
C) is 200 rad/s
D) is 1140 rad/s
E) cannot be computed unless the value of M is given

25. An object attached to one end of a spring makes 20 vibrations in 10 s. Its frequency is:

A) 2 Hz
B) 10 s
C) 0.05 Hz
D) 2 s
E) 0.50 s

Answer Key

1. E
2. B
3. E
4. C
5. B
6. B
7. B
8. E
9. D
10. C
11. C
12. E
13. C
14. E
15. D
16. A
17. D
18. B
19. C
20. E
21. B
22. D
23. B
24. B
25. A

Name: ___________________________ Date: _____________

1. A 40-cm long string, with one end clamped and the other free to move transversely, is vibrating in its fundamental standing wave mode. If the wave speed is 320 cm/s the frequency is:

A) 32 Hz
B) 16 Hz
C) 8 Hz
D) 4 Hz
E) 2 Hz

2. A long string is constructed by joining the ends of two shorter strings. The tension in the strings is the same but string I has 4 times the linear density of string II. When a sinusoidal wave passes from string I to string II:

A) the frequency decreases by a factor of 4
B) the frequency decreases by a factor of 2
C) the wave speed decreases by a factor of 4
D) the wave speed decreases by a factor of 2
E) the wave speed increases by a factor of 2

3. Sinusoidal waves travel on five different strings, all with the same tension. Four of the strings have the same linear mass density, but the fifth has a different linear mass density. Use the mathematical forms of the waves, given below, to identify the string with the different linear mass density. In the expressions x and y are in centimeters and t is in seconds.

A) $y(x, t) = (2\text{ cm}) \sin(2x - 4t)$
B) $y(x, t) = (2\text{ cm}) \sin(4x - 10t)$
C) $y(x, t) = (2\text{ cm}) \sin(6x - 12t)$
D) $y(x,t) = (2\text{ cm}) \sin(8x-16t)$
E) $y(x,t) = (2\text{ cm}) \sin(10x-20t)$

4. The time required for a small pulse to travel from A to B on a stretched cord shown is NOT altered by changing:

A) the linear density of the cord
B) the length between A and B
C) the shape of the pulse
D) the tension in the cord
E) none of the above (changes in all alter the time)

5. The speed of a sinusoidal wave on a string depends on:

A) the frequency of the wave
B) the wavelength of the wave
C) the length of the string
D) the tension in the string
E) the amplitude of the wave

6. A string of length L is clamped at each end and vibrates in a standing wave pattern. The wavelengths of the constituent traveling waves CANNOT be:

A) L
B) $2L$
C) $L/2$
D) $2L/3$
E) $4L$

7. For a transverse wave on a string the string displacement is described by $y(x,t) = f(x - at)$, where f is a given function and a is a positive constant. Which of the following does NOT necessarily follow from this statement?

A) The shape of the string at time $t = 0$ is given by $f(x)$.
B) The shape of the waveform does not change as it moves along the string.
C) The waveform moves in the positive x direction.
D) The speed of the waveform is a.
E) The speed of the waveform is x/t.

8. A string, clamped at its ends, vibrates in three segments. The string is 100 cm long. The wavelength is:

A) 33.3 cm
B) 66.7 cm
C) 150 cm
D) 300 cm
E) need to know the frequency

9. The displacement of a string is given by

$$y(x, t) = Y \sin (kx + \omega t) .$$

speed of the wave is:

A) $2\pi k/\omega$
B) ω/k
C) ωk
D) $2\pi/k$
E) $k/2\pi$

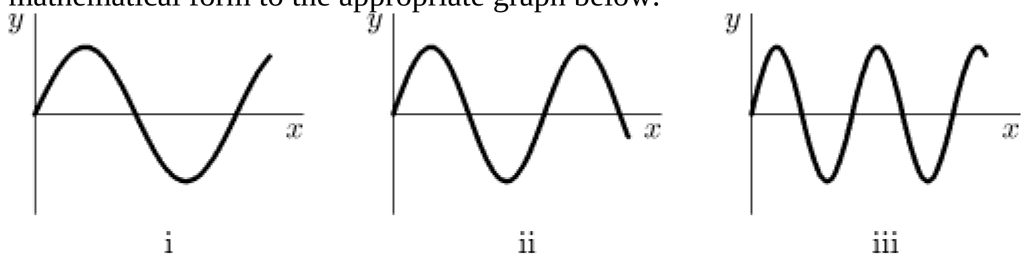
10. Two sinusoidal waves have the same angular frequency, the same amplitude Y, and travel in the same direction in the same medium. If they differ in phase by 50°, the amplitude of the resultant wave is given by:

A) $0.64Y$
B) $1.3Y$
C) $0.91Y$
D) $1.8Y$
E) $0.35Y$

11. Suppose the maximum speed of a string carrying a sinusoidal wave is V^{string}. When the displacement of a point on the string is half its maximum, the speed of the point is:

A) $V^{\text{string}}/2$
B) $2V^{\text{string}}$
C) $V^{\text{string}}/4$
D) $3V^{\text{string}}/4$
E) $\sqrt{3}V^{\text{string}}/2$

12. Three traveling sinusoidal waves are on identical strings, with the same tension. The mathematical forms of the waves are $y_1(x, t) = Y \sin(3x - 6t)$, $y_2(x, t) = Y \sin(4x - 8t)$, and $y_3(x, t) = Y \sin(6x - 12t)$, where x is in meters and t is in seconds. Match each mathematical form to the appropriate graph below.



A) y_1: i, y_2: ii, y_3: iii
B) y_1: iii, y_2: ii, y_3: i
C) y_1: i, y_2: iii, y_3: ii
D) y_1: ii, y_2: i, y_3: iii
E) y_1: iii, y_2: i, y_3: ii

13. The sinusoidal wave

$$y(x, t) = Y \sin(kx - \omega t)$$

incident on the fixed end of a string at $x = L$. The reflected wave is given by:

A) $Y \sin(kx + \omega t)$
B) $-Y \sin(kx + \omega t)$
C) $Y \sin(kx + \omega t - kL)$
D) $Y \sin(kx + \omega t - 2kL)$
E) $-Y \sin(kx + \omega t + 2kL)$

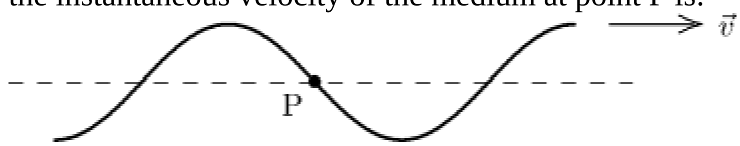
14. A standing wave:

A) can be constructed from two similar waves traveling in opposite directions
B) must be transverse
C) must be longitudinal
D) has motionless points that are closer than half a wavelength
E) has a wave velocity that differs by a factor of two from what it would be for a traveling wave

15. When a string is vibrating in a standing wave pattern the power transmitted across an antinode, compared to the power transmitted across a node, is:

A) more
B) less
C) the same (zero)
D) the same (non–zero)
E) sometimes more, sometimes less, and sometimes the same

16. The transverse wave shown is traveling from left to right in a medium. The direction of the instantaneous velocity of the medium at point P is:



A) ↑
B) ↓
C) →
D) ↗
E) no direction since $v = 0$

17. Let f be the frequency, v^{wave} the speed, and T the period of a sinusoidal traveling wave. The angular frequency is given by:

A) $1/T$
B) $2\pi/T$
C) $v^{\text{wave}}T$
D) f/T
E) T/f

18. When a certain string is clamped at both ends, the lowest four resonant frequencies are measured to be 100, 150, 200, and 250 Hz. One of the resonant frequencies (below 200 Hz) is missing. What is it?

A) 25 Hz
B) 50 Hz
C) 75 Hz
D) 125 Hz
E) 225 Hz

19. A wave on a stretched string is reflected from a fixed end P of the string. The phase difference, at P, between the incident and reflected waves is:

A) zero
B) π rad
C) $\pi/2$ rad
D) depends on the velocity of the wave
E) depends on the frequency of the wave

20. The displacement of a string is given by

$$y(x, t) = Y \sin (kx + \omega t) .$$

wavelength of the wave is:

A) $2\pi k/\omega$
B) k/ω
C) ωk
D) $2\pi/k$
E) $k/2\pi$

21. Sinusoidal water waves are generated in a large ripple tank. The waves travel at 20 cm/s and their adjacent crests are 5.0 cm apart. The time required for each new whole cycle to be generated is:

A) 100 s
B) 4.0 s
C) 2.0 s
D) 0.5 s
E) 0.25 s

22. A wave is described by $y(x, t) = 0.1 \sin (3x + 10t)$, where x is in meters, y is in centimeters, and t is in seconds. The angular wave number is:

A) 0.10 rad/m
B) 3π rad/m
C) 10) rad/m
D) 10π) rad/m
E) 3.0 rad/cm

23. The displacement of a string carrying a traveling sinusoidal wave is given by

$$y(x, t) = Y \sin (kx - \omega t - \phi_0) .$$

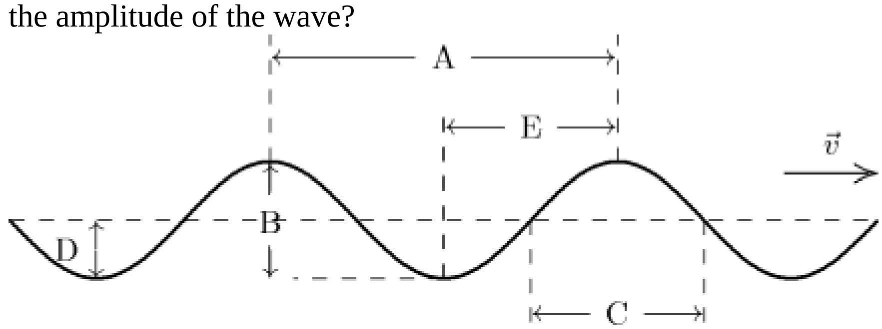
time $t = 0$ the point at $x = 0$ has a velocity of 0 and a positive displacement. The phase constant ϕ_0 is:

A) 45º
B) 90º
C) 135º
D) 180º
E) 270º

24. A transverse traveling sinusoidal wave on a string has a frequency of 100 Hz, a wavelength of 0.040 m, and an amplitude of 2.0 mm. The maximum velocity in m/s of any point on the string is:

A) 0.2
B) 1.3
C) 4
D) 15
E) 25

25. A sinusoidal wave is traveling toward the right as shown. Which letter correctly labels the amplitude of the wave?



A) A
B) B
C) C
D) D
E) E

Answer Key

1. E
2. E
3. B
4. C
5. D
6. E
7. E
8. B
9. B
10. D
11. E
12. A
13. D
14. A
15. C
16. A
17. B
18. B
19. B
20. D
21. E
22. E
23. E
24. B
25. D

Name: ___________________________ Date: _____________

1. An organ pipe with both ends open is 0.85 m long. Assuming that the speed of sound is 340 m/s, the frequency of the third harmonic of this pipe is:

A) 200 Hz
B) 300 Hz
C) 400 Hz
D) 600 Hz
E) none of these

2. "Beats" in sound refer to:

A) interference of two waves of the same frequency
B) combination of two waves of slightly different frequency
C) reversal of phase of reflected wave relative to incident wave
D) two media having slightly different sound velocities
E) effect of relative motion of source and observer

3. The lowest tone produced by a certain organ comes from a 3.0-m pipe with both ends open. If the speed of sound is 340 m/s, the frequency of this tone is approximately:

A) 7 Hz
B) 14 Hz
C) 28 Hz
D) 57 Hz
E) 70 Hz

4. If the speed of sound is 340 m/s, the length of the shortest closed pipe that resonates at 218 Hz is:

A) 23 cm
B) 17 cm
C) 39 cm
D) 78 cm
E) 1.56 cm

5. Two identical strings, A and B, have nearly the same tension. When they both vibrate in their fundamental resonant modes, there is a beat frequency of 3 Hz. When string B is tightened slightly, to increase the tension, the beat frequency becomes 6 Hz. This means:

A) that before tightening A had a higher frequency than B, but after tightening, B has a higher frequency than A
B) that before tightening B had a higher frequency than A, but after tightening, A has a higher frequency than B
C) that before and after tightening A has a higher frequency than B
D) that before and after tightening B has a higher frequency than A
E) none of the above

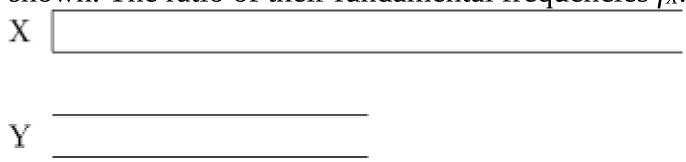
6. A source emits sound with a frequency of 1000 Hz. Both it and an observer are moving toward each other, each with a speed of 100 m/s. If the speed of sound is 340 m/s, the observer hears sound with a frequency of:

A) 294 Hz
B) 545 Hz
C) 1000 Hz
D) 1830 Hz
E) 3400 Hz

7. A vibrating tuning fork is held over a water column with one end closed and the other open. As the water level is allowed to fall, a loud sound is heard for water levels separated by 17 cm. If the speed of sound in air is 340 m/s, the frequency of the tuning fork is:

A) 500 Hz
B) 1000 Hz
C) 2000 Hz
D) 5780 Hz
E) 578,000 Hz

8. Organ pipe Y (open at both ends) is half as long as organ pipe X (open at one end) as shown. The ratio of their fundamental frequencies f_X:f_Y is:



A) 1:1
B) 1:2
C) 2:1
D) 1:4
E) 4:1

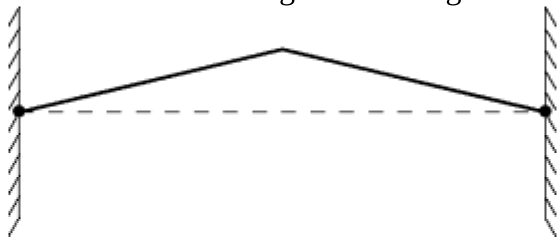
9. A 1024 Hz tuning fork is used to obtain a series of resonance levels in a gas column of variable length, with one end closed and the other open. The length of the column changes by 20 cm from resonance to resonance. From this data, the speed of sound in this gas is:

A) 20 cm/s
B) 51 cm/s
C) 102 cm/s
D) 205 m/s
E) 410 m/s

10. An organ pipe with one end closed and the other open has length L. Its fundamental frequency is proportional to:

A) L
B) $1/L$
C) $1/L^2$
D) L^2
E) $\sqrt{L}$

11. A stretched wire of length 1.0 m is clamped at both ends. It is plucked at its center as shown. The three longest wavelengths in the wire are:



A) 4, 2, 1 m
B) 2, 1, 0.5 m
C) 2, 0.67, 0.4 m
D) 1, 0.5, 0.33 m
E) 1, 0.67, 0.5 m

12. A piano wire has a length of 81 cm and a mass of 2.0 g. If its fundamental frequency is to be 394 Hz, its tension must be:

A) 0.32 N
B) 63 N
C) 130 N
D) 250 N
E) none of these

13. Two stationary tuning forks (350 and 352 Hz) are struck simultaneously. The resulting sound is observed to:

A) beat with a frequency of 2 beats/s
B) beat with a frequency of 351 beats/s
C) be loud but not beat
D) be Doppler shifted by 2 Hz
E) have a frequency of 702 Hz

14. If the speed of sound is 340 m/s, the two lowest frequencies of an 0.5-m organ pipe, closed at one end, are approximately:

A) 170 and 340 Hz
B) 170 and 510 Hz
C) 340 and 680 Hz
D) 340 and 1020 Hz
E) 57 and 170 Hz

15. If the sound level is increased by 10 db the intensity increases by a factor of:

A) 2
B) 5
C) 10
D) 20
E) 100

16. A sound wave has a wavelength of 3.0 m. The distance from a compression center to the adjacent rarefaction center is:

A) 0.75 m
B) 1.5 m
C) 3.0 m
D) need to know wave speed
E) need to know frequency

17. A source emits sound with a frequency of 1000 Hz. It and an observer are moving in the same direction with the same speed, 100 m/s. If the speed of sound is 340 m/s, the observer hears sound with a frequency of:

A) 294 Hz
B) 545 Hz
C) 1000 Hz
D) 1830 Hz
E) 3400 Hz

18. Consider two imaginary spherical surfaces with different radii, each centered on a point sound source emitting spherical waves. The power transmitted across the larger sphere is ______ the power transmitted across the smaller and the intensity at a point on the larger sphere is ______ the intensity at a point on the smaller.

A) greater than, the same as
B) greater than, greater than
C) greater than, less than
D) the same as, less than
E) the same as, the same as

19. Two identical tuning forks vibrate at 256 Hz. One of them is then loaded with a drop of wax, after which 6 beats/s are heard. The period of the loaded tuning fork is:

A) 0.006 s
B) 0.005 s
C) 0.004 s
D) 0.003 s
E) none of these

20. In each of the following two situations a source emits sound with a frequency of 1000 Hz. In situation I the source is moving at 100 m/s toward an observer at rest. In situation II the observer is moving at 100 m/s toward the source, which is stationary. The speed of sound is 340 m/s. The frequencies heard by the observers in the two situations are:

A) I: 1417 Hz; II: 1294 Hz
B) I: 1417 Hz; II: 1417 Hz
C) I: 1294 Hz; II: 1294 Hz
D) I: 773 Hz; II: 706 Hz
E) I: 773 Hz; II: 773 Hz

21. Two notes are an “octave” apart. The ratio of their frequencies is:

A) 8
B) 10
C) $\sqrt{8}$
D) 2
E) $\sqrt{2}$

22. When listening to tuning forks of frequency 256 Hz and 260 Hz, one hears the following number of beats per second:

A) zero
B) 2
C) 4
D) 8
E) 258

23. A tuning fork produces sound waves of wavelength λ in air. This sound is used to cause resonance in an air column, closed at one end and open at the other. The length of this column CANNOT be:

A) $\lambda/4$
B) $2\lambda/4$
C) $3\lambda/4$
D) $5\lambda/4$
E) $7\lambda/4$

24. At points in a sound wave where the gas is maximally compressed, the pressure

A) is a maximum
B) is a minimum
C) is equal to the ambient value
D) is greater than the ambient value but less than the maximum
E) is less than the ambient value but greater than the minimum

25. The standard reference sound level is about:

A) the threshold of human hearing at 1000 Hz
B) the threshold of pain for human hearing at 1000 Hz
C) the level of sound produced when the 1 kg standard mass is dropped 1 m onto a concrete floor
D) the level of normal conversation
E) the level of sound emitted by a standard 60 Hz tuning fork

Answer Key

1. D
2. B
3. D
4. C
5. D
6. D
7. B
8. A
9. E
10. B
11. C
12. B
13. A
14. B
15. C
16. B
17. C
18. D
19. C
20. A
21. D
22. C
23. B
24. A
25. A

Name: ___________________________ Date: _____________

1. Constant-volume gas thermometers using different gases all indicate nearly the same temperature when in contact with the same object if:

A) the volumes are all extremely large
B) the volumes are all the same
C) the pressures are all extremely large
D) the pressures are the same
E) the particle concentrations are all extremely small

2. Suppose object C is in thermal equilibrium with object A and with object B. The zeroth law of thermodynamics states:

A) that C will always be in thermal equilibrium with both A and B
B) that C must transfer energy to both A and B
C) that A is in thermal equilibrium with B
D) that A cannot be in thermal equilibrium with B
E) nothing about the relationship between A and B

3. To help keep buildings cool in the summer, dark colored window shades have been replaced by light colored shades. This is because light colored shades:

A) are more pleasing to the eye
B) absorb more sunlight
C) reflect more sunlight
D) transmit more sunlight
E) have a lower thermal conductivity

4. Inside a room at a uniform comfortable temperature, metallic objects generally feel cooler to the touch than wooden objects do. This is because:

A) a given mass of wood contains more thermal energy than the same mass of metal
B) metal conducts energy better than wood
C) energy tends to flow from metal to wood
D) the equilibrium temperature of metal in the room is lower than that of wood
E) the human body, being organic, resembles wood more closely than it resembles metal

5. Possible units for the coefficient of volume expansion are:

A) mm/C^{o}
B) mm^3/C^{o}
C) (C^{o})^3
D) 1/(C^{o})^3
E) 1/C^{o}

6. Room temperature is about 20 degrees on the:

A) Kelvin scale
B) Celsius scale
C) Fahrenheit scale
D) absolute scale
E) C major scale

7. When two gases separated by a thermally conducting wall are in thermal equilibrium with each other:

A) only their pressures must be the same
B) only their volumes must be the same
C) they must have the same number of particles
D) they must have the same pressure and the same volume
E) only their temperatures must be the same

8. In an adiabatic process:

A) the thermal energy absorbed equals the work done by the system on its environment
B) the thermal energy equals the work done by the environment on the system
C) the thermal energy absorbed equals the change in internal energy
D) the work done by the environment on the system equals the change in internal energy
E) the work done by the system on its environment equals to the change in internal energy

9. A Kelvin thermometer and a Fahrenheit thermometer both give the same reading for a certain sample. The corresponding Celsius temperature is:

A) 574º C
B) 232º C
C) 301º C
D) 614º C
E) 276º C

10. Which of the following statements pertaining to a vacuum flask (Thermos) is NOT correct?

A) Silvering reduces radiation loss
B) Vacuum reduces conduction loss
C) Vacuum reduces convection loss
D) Vacuum reduces radiation loss
E) Glass walls reduce conduction loss

11. For constant-volume processes the heat capacity of gas A is greater than the heat capacity of gas B. We conclude that when they both absorb the same thermal energy at constant volume:

A) the temperature of A increases more than the temperature of B
B) the temperature of B increases more than the temperature of A
C) the internal energy of A increases more than the internal energy of B
D) the internal energy of B increases more than the internal energy of A
E) A does more positive work than B

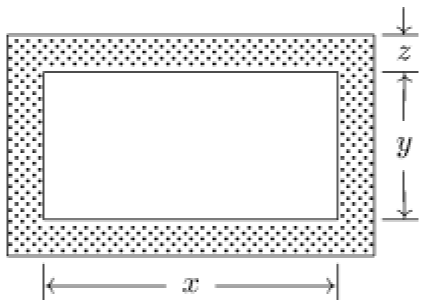
12. The heat capacity of an object is:

A) the amount of thermal energy that raises its temperature by 1º C
B) the amount of thermal energy that changes its state without changing its temperature
C) the amount of thermal energy per kilogram that raises its temperature by 1º C
D) the ratio of its specific heat to that of water
E) the change in its temperature caused by adding 1 J of thermal energy

13. The coefficient of linear expansion of iron is 1.0×10^{-5} per C° . The surface area of an iron cube, with an edge length of 5.0 cm, will increase by what amount if it is heated from 10° C to 60° C?

A) 0.0125 cm^2
B) 0.025 cm^2
C) 0.075 cm^2
D) 0.15 cm^2
E) 0.30 cm^2

14. The figure shows a rectangular brass plate at 0° C in which there is cut a rectangular hole of dimensions indicated. If the temperature of the plate is raised to 150° C:



A) *x* will increase and *y* will decrease
B) both *x* and *y* will decrease
C) *x* will decrease and *y* will increase
D) both *x* and *y* will increase
E) the changes in *x* and *y* depend on the dimension *z*

15. The specific heat of lead is 0.030 cal/g · C°. 300 g of lead shot at 100° C is mixed with 100 g of water at 70° C in an insulated container. The final temperature of the mixture is:

A) 100° C
B) 85.5° C
C) 79.5° C
D) 74.5° C
E) 72.5° C

16. The mercury column in an ordinary medical thermometer doubles in length when its temperature changes from 95º F to 105º F. Choose the correct statement:

A) the coefficient of volume expansion of mercury is 0.1 per Fº
B) the coefficient of volume expansion of mercury is 0.3 per Fº
C) the coefficient of volume expansion of mercury is (0.1/3) per Fº
D) the vacuum above the column helps to “pull up” the mercury this large amount
E) none of the above is true

17. On a very cold day, a child puts his tongue against a fence post. It is much more likely that his tongue will stick to a steel post than to a wooden post. This is because:

A) steel has a higher specific heat
B) steel is a better radiator of thermal energy
C) steel has a higher specific gravity
D) steel is a better energy conductor
E) steel is a highly magnetic material

18. Of the following which might NOT vanish over one cycle of a cyclic process?

A) the change ΔE^{int} in internal energy
B) the change ΔP in pressure
C) the work W by the substance
D) the change ΔV in the volume of the substance
E) the change ΔT in the temperature of the substance

19. The same thermal energy Q enters five different substances.
Which substance has the greatest specific heat?

A) The temperature of 3 g of substance A increases by 10 K
B) The temperature of 4 g of substance B increases by 4 K
C) The temperature of 6 g of substance C increases by 15 K
D) The temperature of 8 g of substance D increases by 6 K
E) The temperature of 10 g of substance E increases by 10 K

20. A constant-volume gas thermometer is used to measure the temperature of an object. When the thermometer is in contact with water at its triple point (273.16 K) the pressure in the thermometer is 8.500×10^4 Pa. When it is in contact with the object the pressure is 9.650×10^4 Pa. The temperature of the object is:

A) 37.0 K
B) 241 K
C) 310 K
D) 314 K
E) 2020 K

21. The coefficient of linear expansion of a certain steel is 0.000012 per C° . The coefficient of volume expansion, in $(C°)^{-1}$, is:

A) $(0.000012)^3$
B) $(4\pi/3)(0.000012)^3$
C) 3×0.000012
D) 0.000012
E) depends on the shape of the volume to which it will be applied

22. Two different samples have the same mass and temperature. Equal quantities of thermal energy are absorbed by each. Their final temperatures may be different because the samples have different:

A) thermal conductivities
B) coefficients of expansion
C) densities
D) volumes
E) heat capacities

23. There is a temperature at which the reading on the Kelvin scale is numerically:

A) equal to that on the Celsius scale
B) lower than that on the Celsius scale
C) equal to that on the Fahrenheit scale
D) less than zero
E) none of the above

24. The heat capacity of object B is twice that of object A. Initially A is at 300 K and B is at 450 K. They are placed in thermal contact and the combination is isolated. The final temperature of both objects is:

A) 200 K
B) 300 K
C) 400 K
D) 450 K
E) 600 K

25. The coefficient of linear expansion of steel is 11×10^{-6} per C° . A steel ball has a volume of exactly 100 cm^3 at 0° C. When heated to 100° C, its volume becomes:

A) 100.33 cm^3
B) 100.0011 cm^3
C) 100.0033 cm^3
D) 100.000011 cm^3
E) none of these

Answer Key

1. E
2. C
3. C
4. B
5. E
6. B
7. E
8. D
9. C
10. D
11. B
12. A
13. D
14. D
15. E
16. E
17. D
18. C
19. B
20. C
21. C
22. E
23. C
24. C
25. A

Name: ___________________________ Date: _____________

1. In order that a single process be both isothermal and isobaric:

A) one must use an ideal gas
B) such a process is impossible
C) a change of phase is essential
D) one may use any real gas such as N_2
E) one must use a solid

2. The pressure of an ideal gas is doubled during a process in which the energy given up as heat by the gas equals the work done on the gas. As a result, the volume is:

A) doubled
B) halved
C) unchanged
D) need more information to answer
E) nonsense; the process is impossible

3. A gas is confined to a cylindrical container of radius 1 cm and length 1 m. The pressure exerted on an end face, compared with the pressure exerted on the long curved face, is:

A) smaller because its area is smaller
B) smaller because most molecules cannot traverse the length of the cylinder without undergoing collisions
C) larger because the face is flat
D) larger because the molecules have a greater distance in which to accelerate before they strike the face
E) none of these

4. The speeds of 25 molecules are distributed as follows: 5 in the range from 2 to 3 m/s, 10 in the range from 3 to 4 m/s, 5 in the range from 4 to 5 m/s, 3 in the range from 5 to 6 m/s, 1 in the range from 6 to 7 m/s, and 1 in the range from 7 to 8 m/s. Their average speed is about:

A) 2 m/s
B) 3 m/s
C) 4 m/s
D) 5 m/s
E) 6 m/s

5. Two ideal gases, each consisting of N monatomic molecules, are in thermal equilibrium with each other and equilibrium is maintained as the temperature is increased. A molecule of the first gas has mass m and a molecule of the second has mass $4m$. The ratio of the changes in the internal energies $\Delta E_{4m}/\Delta E_m$ is:

A) 1/4
B) 1/2
C) 1
D) 2
E) 4

6. The mean free path of molecules in a gas is proportional to:

A) the molecular cross-sectional area
B) the reciprocal of the molecular cross-sectional area
C) the root-mean-square molecular speed
D) the square of the average molecular speed
E) the molar mass

7. The "Principle of Equipartition of Energy" states that the internal energy of a gas is shared equally:

A) among the molecules
B) between kinetic and potential energy
C) among the relevant degrees of freedom
D) between translational and vibrational kinetic energy
E) between temperature and pressure

8. An automobile tire is pumped up to a gauge pressure of 2.0×10^5 Pa when the temperature is 27º C. What is its gauge pressure after the car has been running on a hot day so that the tire temperature is 77º C? Assume that the volume remains fixed and take atmospheric pressure to be 1.013×10^5 Pa.

A) 1.6×10^5 Pa
B) 2.6×10^5 Pa
C) 3.6×10^5 Pa
D) 5.9×10^5 Pa
E) 7.9×10^5 Pa

9. An ideal gas of N monatomic molecules is in thermal equilibrium with an ideal gas of the same number of diatomic molecules and equilibrium is maintained as the temperature is increased. The ratio of the changes in the internal energies $\Delta E_{\text{dia}}/\Delta E_{\text{mon}}$ is:

A) 1/2
B) 3/5
C) 1
D) 5/3
E) 2

10. The number of degrees of freedom of a triatomic molecule is:

A) 1
B) 3
C) 6
D) 8
E) 9

11. A real gas is changed slowly from state 1 to state 2. During this process no work is done on or by the gas. This process must be:

A) isothermal
B) adiabatic
C) isovolumic
D) isobaric
E) a closed cycle with state 1 coinciding with state 2

12. The ratio of the specific heat of an ideal gas at constant volume to its specific heat at constant pressure is:

A) R
B) $1/R$
C) dependent on the temperature
D) dependent on the pressure
E) different for monatomic, diatomic, and polyatomic gases

13. The temperature of a gas is most closely related to:

A) the kinetic energy of translation of its molecules
B) its total molecular kinetic energy
C) the sizes of its molecules
D) the potential energy of its molecules
E) the total energy of its molecules

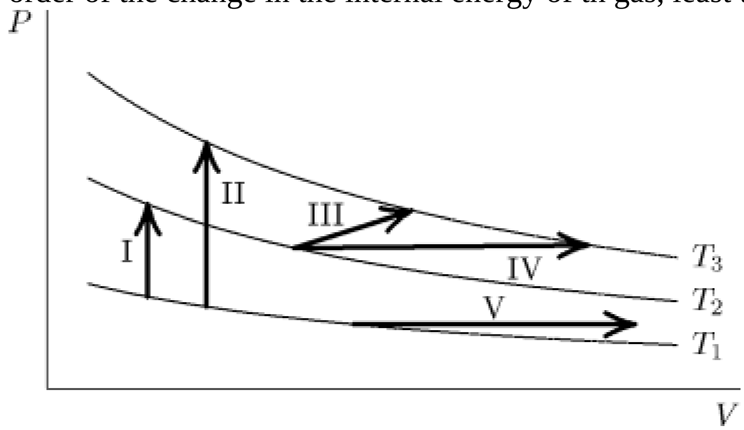
14. It is known that 28 g of a certain ideal gas occupy 22.4 liters at standard conditions (0º C, 1 atm). The volume occupied by 42 g of this gas at standard conditions is:

A) 14.9 liters
B) 22.4 liters
C) 33.6 liters
D) 42 liters
E) more data are needed

15. During a slow adiabatic expansion of a gas:

A) the pressure remains constant
B) energy is added as heat
C) work is done on the gas
D) no energy enters or leaves as heat
E) the temperature is constant

16. The diagram shows three isotherms for an ideal gas, with $T_3 - T_2$ the same as $T_2 - T_1$. It also shows five thermodynamic processes carried out on the gas. Rank the processes in order of the change in the internal energy of th gas, least to greatest.



A) I, II, III, IV, V
B) V, then I, III, and IV tied, then II
C) V, I, then III and IV tied, then II
D) IV, V, III, I, II
E) II, I, then III, IV, and V tied

17. An ideal gas has molar specific heat C_p at constant pressure. When the temperature of n moles is increased by ΔT the increase in the internal energy is:

A) $nC_p \Delta T$
B) $n(C_p + R) \Delta T$
C) $n(C_p - R) \Delta T$
D) $n(2C_p + R) \Delta T$
E) $n(2C_p - R) \Delta T$

18. When work W is done on an ideal gas of diatomic molecules in thermal isolation the increase in the total translational kinetic energy of the molecules is:

A) 0
B) $2W/3$
C) $2W/5$
D) $3W/5$
E) W

19. A system consists of N gas molecules each of mass m. Their rms speed is v^{rms}. Their total translational kinetic energy is:

A) $(1/2)m(Nv^{\text{rms}})^2$
B) $(1/2)N(mv^{\text{rms}})^2$
C) $(1/2)m(v^{\text{rms}})^2$
D) $(1/2)N(mv^{\text{rms}})^2$
E) $N[(1/2)mv^{\text{rms}}]^2$

20. The temperature of n moles of an ideal monatomic gas is increased by ΔT at constant pressure. The thermal energy Q absorbed, change ΔE_{int} in internal energy, and work W done by the environment are given by:

A) $Q = (5/2)nR\,\Delta T$, $\Delta E_{\text{int}} = 0$, $W = -nR\,\Delta T$
B) $Q = (3/2)nR\,\Delta T$, $\Delta E_{\text{int}} = (5/2)nR\,\Delta T$, $W = -(3/2)nR\,\Delta T$
C) $Q = (5/2)nR\,\Delta T$, $\Delta E_{\text{int}} = (5/2)nR\,\Delta T$, $W = 0$
D) $Q = (3/2)nR\,\Delta T$, $\Delta E_{\text{int}} = 0$, $W = -nR\,\Delta T$
E) $Q = (5/2)nR\,\Delta T$, $\Delta E_{\text{int}} = (3/2)nR\,\Delta T$, $W = -nR\,\Delta T$

21. The mean free path of air molecules near the surface of Earth is about:

A) 10^{-9} m
B) 10^{-7} m
C) 10^{-5} m
D) 10^{-3} m
E) 10^{-1} m

22. Over 1 cycle of a cyclic process in which a system does net work on its environment:

A) the change in the pressure of the system cannot be zero
B) the change in the volume of the system cannot be zero
C) the change in the temperature of the system cannot be zero
D) the change in the internal energy of the system cannot be zero
E) none of the above

23. The pressure of an ideal gas is doubled in an isothermal process. The root-mean-square speed of the molecules:

A) does not change
B) increases by a factor of $\sqrt{2}$
C) decreases by a factor of $1/\sqrt{2}$
D) increases by a factor of 2
E) decreases by a factor of 1/2

24. Two identical rooms in a house are connected by an open doorway. The temperatures in the two rooms are maintained at different values. Which room contains more air?

A) the room with higher temperature
B) the room with lower temperature
C) the room with higher pressure
D) neither because both have the same pressure
E) neither because both have the same volume

25. When work W is done on an ideal gas of N diatomic molecules in thermal isolation the temperature increases by:

A) $W/2Nk$
B) $W/3Nk$
C) $2W/3Nk$
D) $2W/5Nk$
E) W/Nk

Answer Key

1. C
2. B
3. E
4. C
5. C
6. B
7. C
8. A
9. D
10. E
11. C
12. E
13. A
14. C
15. D
16. B
17. C
18. D
19. D
20. E
21. B
22. E
23. A
24. B
25. D

Name: ___________________________ Date: _____________

1. Let k be the Boltzmann constant. If the configuration of the molecules in a gas changes so that the multiplicity is reduced to one-third its previous value, the entropy of the gas changes by:

A) $\Delta S = 0$
B) $\Delta S = 3k \ln 2$
C) $\Delta S = -3k \ln 2$
D) $\Delta S = -k \ln 3$
E) $\Delta S = k \ln 3$

2. Consider the following processes: The temperature of two identical gases are increased from the same initial temperature to the same final temperature. Reversible processes are used. For gas A the process is carried out at constant volume while for gas B it is carried out at constant pressure. The change in entropy:

A) is the same for A and B
B) is greater for A
C) is greater for B
D) is greater for A only if the initial temperature is low
E) is greater for A only if the initial temperature is high

3. In a reversible process the system:

A) is always close to equilibrium states
B) is close to equilibrium states only at the beginning and end
C) might never be close to any equilibrium state
D) is close to equilibrium states throughout, except at the beginning and end
E) is none of the above

4. An engine that in each cycle does positive work and rejects thermal energy, with no thermal energy input, would violate:

A) the zeroth law of thermodynamics
B) the first law of thermodynamics
C) the second law of thermodynamics
D) the third law of thermodynamics
E) Newton's second law

5. For all irreversible processes involving a system and its environment:

A) the entropy of the system does not change
B) the entropy of the system increases
C) the total entropy of the system and its environment does not change
D) the total entropy of the system and its environment increases
E) none of the above

6. An inventor suggests that a house might be heated by using a refrigerator to draw energy as heat from the ground and reject energy as heat into the house. He claims that the energy supplied to the house as heat can exceed the work required to run the refrigerator. This:

A) is impossible by first law
B) is impossible by second law
C) would only work if the ground and the house were at the same temperature
D) is impossible since heat energy flows from the (hot) house to the (cold) ground
E) is possible

7. The change in entropy is zero for:

A) reversible adiabatic processes
B) reversible isothermal processes
C) reversible processes during which no work is done
D) reversible isobaric processes
E) all adiabatic processes

8. A Carnot engine operates between 400 K and 500 K. Its efficiency is:

A) 20%
B) 25%
C) 44%
D) 79%
E) 100%

9. A slow (quasi-static) process is NOT reversible if:

A) the temperature changes
B) energy is absorbed or emitted as heat
C) work is done on the system
D) friction is present
E) the pressure changes

10. A cyclical process that transfers thermal energy from a high temperature reservoir to a low temperature reservoir with no other change would violate:

A) the zeroth law of thermodynamics
B) the first law of thermodynamics
C) the second law of thermodynamics
D) the third law of thermodynamics
E) none of the above

11. Let k be the Boltzmann constant. If the configuration of molecules in a gas changes from one with a multiplicity of M_1 to one with a multiplicity of M_2, then entropy changes by:

A) $\Delta S = 0$
B) $\Delta S = k(M_2 - M_1)$
C) $\Delta S = kM_2/M_1$
D) $\Delta S = k \ln (M_2 M_1)$
E) $\Delta S = k \ln (M_2/M_1)$

12. For all reversible processes involving a system and its environment:

A) the entropy of the system does not change
B) the entropy of the system increases
C) the total entropy of the system and its environment does not change
D) the total entropy of the system and its environment increases
E) none of the above

13. An engine in each cycle absorbs thermal energy from a reservoir and does an equivalent amount of work, with no other changes. This engine violates:

A) the zeroth law of thermodynamics
B) the first law of thermodynamics
C) the second law of thermodynamics
D) the third law of thermodynamics
E) none of the above

14. An engine absorbs thermal energy of magnitude $|Q_H|$ from a high temperature reservoir, does work of magnitude $|W|$, and rejects thermal energy of magnitude $|Q_L|$ to a low temperature reservoir. Its efficiency is:

A) $|Q_H|/|W|$
B) $|Q_L|/|W|$
C) $|Q_H|/|Q_L|$
D) $|W|/|Q_H|$
E) $|W|/|Q_L|$

15. Let S^{irrev} denote the change in entropy of a sample for an irreversible process from state A to state B. Let S^{rev} denote the change in entropy of the same sample for a reversible process from state A to state B. Then:

A) $S^{\text{irrev}} > S^{\text{rev}}$
B) $S^{\text{irrev}} = S^{\text{rev}}$
C) $S^{\text{irrev}} < S^{\text{rev}}$
D) $S^{\text{irrev}} = 0$
E) $S^{\text{rev}} = 0$

16. A hot object and a cold object are placed in thermal contact and the combination is isolated. They transfer energy until they reach a common temperature. The change ΔS_h in the entropy of the hot object, the change ΔS_c in the entropy of the cold object, and the change ΔS^{net} in the entropy of the combination are:

A) $\Delta S_h > 0$, $\Delta S_c > 0$, $\Delta S^{\text{net}} > 0$
B) $\Delta S_h < 0$, $\Delta S_c > 0$, $\Delta S^{\text{net}} > 0$
C) $\Delta S_h < 0$, $\Delta S_c > 0$, $\Delta S^{\text{net}} < 0$
D) $\Delta S_h > 0$, $\Delta S_c < 0$, $\Delta S^{\text{net}} > 0$
E) $\Delta S_h > 0$, $\Delta S_c < 0$, $\Delta S^{\text{net}} < 0$

17. The thermodynamic state of a gas changes from one with 3.8×10^{18} microstates to one with 7.9×10^{19} microstates. The Boltzmann constant is 1.38×10^{-23} J/K. The change in entropy is:

A) $\Delta S = 0$
B) $\Delta S = 1.04 \times 10^{-23}$ J/K
C) $\Delta S = -1.04 \times 10^{-23}$ J/K
D) $\Delta S = 4.19 \times 10^{-23}$ J/K
E) $\Delta S = -4.19 \times 10^{-23}$ J/K

18. One mole of an ideal gas expands reversibly and isothermally at temperature T until its volume is doubled. The change of entropy of this gas for this process is:

A) $R \ln 2$
B) $(\ln 2)/T$
C) 0
D) $RT \ln 2$
E) $2R$

19. According to the second law of thermodynamics:

A) all engines have the same efficiency
B) all reversible engines have the same efficiency
C) the efficiency of any engine is independent of its working substance
D) the efficiency of a Carnot engine depends only on the temperatures of the two reservoirs
E) all Carnot engines theoretically have 100% efficiency

20. A perfectly reversible heat pump with a coefficient of performance of 14 supplies thermal energy to a building to maintain its temperature at 27º C. If the pump motor does work at the rate of 1 kW, at what rate does the pump supply thermal energy to the building?

A) 15 kW
B) 3.85 kW
C) 1.35 kW
D) 1.07 kW
E) 1.02 kW

21. After one complete cycle of a reversible engine, which of the following quantities is NOT zero?

A) the change ΔS of the entropy of the working gas
B) the change ΔP of the pressure of the working gas
C) the change ΔE_{int} of the internal energy of the working gas
D) the work W done by the working gas
E) the change ΔT of the temperature of the working gas

22. An ideal gas expands into a vacuum in a rigid vessel. As a result there is:

A) a change in entropy
B) an increase of pressure
C) a change in temperature
D) a decrease of internal energy
E) a change in phase

23. An Carnot refrigerator runs between a cold reservoir at temperature T_C and a hot reservoir at temperature T_H. You want to increase its coefficient of performance. Of the following, which change results in the greatest increase in the coefficient? The value of ΔT is the same for all changes.

A) Raise the temperature of the hot reservoir by ΔT
B) Raise the temperature of the cold reservoir by ΔT
C) Lower the temperature of the hot reservoir by ΔT
D) Lower the temperature of the cold reservoir by ΔT
E) Lower the temperature of the hot reservoir by $\frac{1}{2}\Delta T$ and raise the temperature of the cold reservoir by $\frac{1}{2}\Delta T$

24. The difference in entropy $\Delta S = S_B - S_A$ for two states A and B of a system can computed as the integral $\int dQ/T$ provided:

A) A and B are on the same adiabat
B) A and B have the same temperature
C) a reversible path is used for the integral
D) the change in internal energy is first computed
E) the energy absorbed as heat by the system is first computed

25. Which of the following is NOT a state variable?

A) Work
B) Internal energy
C) Entropy
D) Temperature
E) Pressure

Answer Key

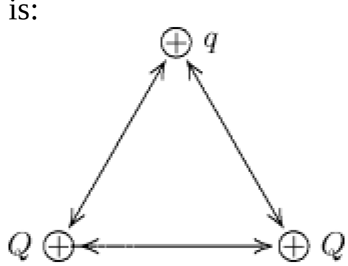
1. D
2. C
3. A
4. B
5. D
6. E
7. A
8. A
9. D
10. E
11. E
12. C
13. C
14. D
15. B
16. B
17. D
18. A
19. D
20. A
21. D
22. A
23. B
24. C
25. A

Name: ___________________________ Date: _____________

1. A conductor is distinguished from an insulator with the same number of atoms by the number of:

A) nearly free atoms
B) electrons
C) nearly free electrons
D) protons
E) molecules

2. Two particles, each with charge *Q*, and a third particle, with charge *q*, are placed at the vertices of an equilateral triangle as shown. The net force on the particle with charge *q* is:



A) parallel to the left side of the triangle
B) parallel to the right side of the triangle
C) parallel to the bottom side of the triangle
D) perpendicular to the bottom side of the triangle
E) perpendicular to the left side of the triangle

3. To make an uncharged object have a net positive charge:

A) remove some neutrons
B) add some neutrons
C) add some electrons
D) remove some electrons
E) heat it to cause a change of phase

4. An electrical insulator is a material:

A) containing no electrons
B) through which electrons do not flow easily
C) that has more electrons than protons on its surface
D) cannot be a pure chemical element
E) must be a crystal

5. Two protons (p_1 and p_2) and an electron (e) lie on a straight line, as shown. The directions of the force of p_1 on e, the force of p_2 on e, and the total force on e, respectively, are:

A) →, ←, →
B) ←, →, →
C) →, ←, ←
D) ←, →, ←
E) ←, ←, ←

6. A negatively charged rubber rod is brought near the knob of a positively charged electroscope. The result is that:

A) the electroscope leaves will move farther apart
B) the rod will lose its charge
C) the electroscope leaves will tend to collapse
D) the electroscope will become discharged
E) nothing noticeable will happen

7. Consider the following procedural steps:
1. ground the electroscope
2. remove the ground from the electroscope
3. touch a charged rod to the electroscope
4. bring a charged rod near, but not touching, the electroscope
5. remove the charged rod
To charge an electroscope by induction, use the sequence:

A) 1, 4, 5, 2
B) 4, 1, 2, 5
C) 3, 1, 2, 5
D) 4, 1, 5, 2
E) 3, 5

8. A positively charged insulating rod is brought close to an object that is suspended by a string. If the object is attracted toward the rod we can conclude:

A) the object is positively charged
B) the object is negatively charged
C) the object is an insulator
D) the object is a conductor
E) none of the above

9. The leaves of a positively charged electroscope diverge more when an object is brought near the knob of the electroscope. The object must be:

A) a conductor
B) an insulator
C) positively charged
D) negatively charged
E) uncharged

10. Two small charged objects attract each other with a force F when separated by a distance d. If the charge on each object is reduced to one-fourth of its original value and the distance between them is reduced to $d/2$ the force becomes:

A) $F/16$
B) $F/8$
C) $F/4$
D) $F/2$
E) F

11. In the Rutherford model of the hydrogen atom, a proton (mass M, charge Q) is the nucleus and an electron (mass m, charge q) moves around the proton in a circle of radius r. Let k denote the Coulomb force constant ($1/4\pi\varepsilon_0$) and G the universal gravitational constant. The ratio of the electrostatic force to the gravitational force between electron and proton is:

A) $kQq/GMmr^2$
B) GQq/kMm
C) kMm/GQq
D) GMm/kQq
E) kQq/GMm

12. A particle with a charge of 5×10^{-6} C and a mass of 20 g moves uniformly with a speed of 7 m/s in a circular orbit around a stationary particle with a charge of -5×10^{-6} C. The radius of the orbit is:

A) 0
B) 0.23 m
C) 0.62 m
D) 1.6
E) 4.4 m

13. A charged insulator can be discharged by passing it just above a flame. This is because the flame:

A) warms it
B) dries it
C) contains carbon dioxide
D) contains ions
E) contains more rapidly moving atoms

14. Charges q_1 and q_2 are on the x axis, with q_1 at $x = a$ and q_2 at $x = -2a$. For the net force on a another charge at the origin to be zero, q_1 and q_2 must be related by q_2 = :

A) $2q_1$
B) $4q_1$
C) $-2q_1$
D) $-4q_1$
E) $-q_1/4$

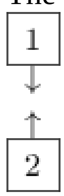
15. The charge on a glass rod that has been rubbed with silk is called positive:

A) by arbitrary convention
B) so that the proton charge will be positive
C) to conform to the conventions adopted for *G* and *m* in Newton's law of gravitation
D) because like charges repel
E) because glass is an insulator

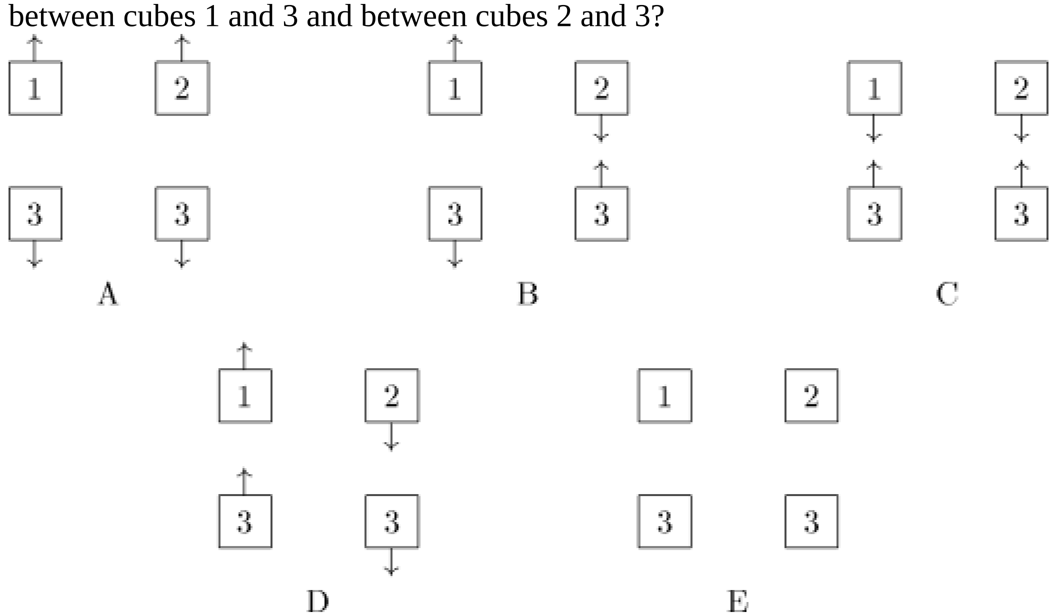
16. A neutral metal ball is suspended by a string. A positively charged insulating rod is placed near the ball, which is observed to be attracted to the rod. This is because:

A) the ball becomes positively charged by induction
B) the ball becomes negatively charged by induction
C) the number of electrons in the ball is more than the number in the rod
D) the string is not a perfect insulator
E) there is a rearrangement of the electrons in the ball

17. The diagram shows a pair of heavily charged plastic cubes that attract each other.



Cube 3 is a conductor and is uncharged. Which of the following illustrates the forces between cubes 1 and 3 and between cubes 2 and 3?



A) A
B) B
C) C
D) D
E) E

18. Charge is distributed uniformly on the surface of a spherical balloon (an insulator) with a point charge q inside. The electrical force on q is greatest when:

A) it is near the inside surface of the balloon
B) it is at the center of the balloon
C) it is halfway between the balloon center and the inside surface
D) it is anywhere inside (the force is same everywhere and is not zero)
E) it is anywhere inside (the force is zero everywhere)

19. Charge Q is on the y axis a distance a from the origin and charge q is on the x axis a distance d from the origin. The value of d for which the x component of the force on q is the greatest is:

A) 0
B) a
C) $\sqrt{2}a$
D) $a/2$
E) $a/\sqrt{2}$

20. Two particles A and B have identical charge Q. For a net force of zero to be exerted on a third charge it must be placed:

A) midway between A and B
B) on the perpendicular bisector of the line joining A and B but away from the line
C) on the line joining A and B, not between the particles
D) on the line joining A and B, closer to one of them than the other
E) at none of these places (there is no place)

21. Two particles, X and Y, are 4 m apart. X has a charge of $2Q$ and Y has a charge of Q. The force of X on Y:

A) has twice the magnitude of the force of Y on X
B) has half the magnitude of the force of Y on X
C) has four times the magnitude of the force of Y on X
D) has one-fourth the magnitude of the force of Y on X
E) has the same magnitude as the force of Y on X

22. A small object has charge Q. Charge q is removed from it and placed on a second small object. The two objects are placed 1 m apart. For the force that each object exerts on the other to be a maximum. q should be:

A) $2Q$
B) Q
C) $Q/2$
D) $Q/4$
E) 0

23. The magnitude of the charge on an electron is approximately:

A) 10^{23} C
B) 10^{-23} C
C) 10^{19} C
D) 10^{-19} C
E) 10^{9} C

24. A 2-μC charge is placed at the origin, an identical charge is placed 2 m from the origin on the x axis, and a third identical charge is placed 2 m from the origin on the y axis. The magnitude of the force on the charge at the origin is:

A) 9.0×10^{-3} N
B) 6.4×10^{-3} N
C) 1.3×10^{-2} N
D) 1.8×10^{-2} N
E) 3.6×10^{-2} N

25. When a hard rubber rod is given a negative charge by rubbing it with wool:

A) positive charges are transferred from rod to wool
B) negative charges are transferred from rod to wool
C) positive charges are transferred from wool to rod
D) negative charges are transferred from wool to rod
E) negative charges are created and stored on the rod

Answer Key

1. C
2. D
3. D
4. B
5. D
6. C
7. B
8. E
9. C
10. C
11. E
12. B
13. D
14. B
15. A
16. E
17. C
18. E
19. E
20. A
21. E
22. C
23. D
24. C
25. D

Name: ___________________________ Date: _____________

1. The dipole moment of an electric dipole in a 300-N/C electric field is initially perpendicular to the field, but it rotates so it is in the same direction as the field. If the moment has a magnitude of 2×10^{-9} C · m, the work done by the field is:

A) -12×10^{-7} J
B) -6×10^{-7} J
C) 0
D) 6×10^{-7} J
E) 12×10^{-7} J

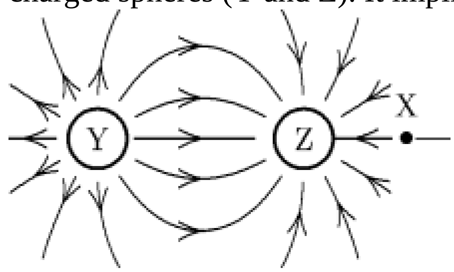
2. A 200-N/C electric field is in the positive *x* direction. The force on an electron in this field is:

A) 200 N in the positive *x* direction
B) 200 N in the negative *x* direction
C) 3.2×10^{-17} N in the positive *x* direction
D) 3.2×10^{-17} N in the negative *x* direction
E) 0

3. The torque exerted by an electric field on an electric dipole is:

A) parallel to the field and perpendicular to the dipole moment
B) parallel to both the field and dipole moment
C) perpendicular to both the field and dipole moment
D) parallel to the dipole moment and perpendicular to the field
E) not related to the directions of the field and dipole moment

4. The diagram shows the electric field lines in a region of space containing two small charged spheres (Y and Z). It implies that:



A) Y is negative and Z is positive
B) the magnitude of the electric field is the same everywhere
C) the electric field is strongest midway between Y and Z
D) the electric field is not zero anywhere (except infinitely far from the spheres)
E) Y and Z must have the same sign

5. A uniform electric field of 300 N/C makes an angle of 25º with the dipole moment of an electric dipole. If the torque exerted by the field has a magnitude of 2.5×10^{-7} N · m, the magnitude of the dipole moment must be:

A) 8.3×10^{-10} C · m
B) 9.2×10^{-10} C · m
C) 2.0×10^{-9} C · m
D) 8.3×10^{-5} C · m
E) 1.8×10^{-4} C · m

6. Choose the correct statement concerning electric field lines:

A) field lines may cross
B) field lines are close together where the field is large
C) field lines point away from a negatively charged particle
D) a charged point particle released from rest moves along a field line
E) none of these are correct

7. Let k denote $1/4\pi\varepsilon_0$. The magnitude of the electric field at a distance r from an isolated point particle with charge q is:

A) kq/r
B) kr/q
C) kq/r^3
D) kq/r^2
E) kq^2/r^2

8. Two charged particles are arranged as shown. In which region could a third particle, with charge + 1 C, be placed so that the net electrostatic force on it is zero?

A) I only
B) I and II only
C) III only
D) I and III only
E) II only

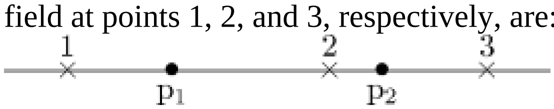
9. A charged particle is placed in an electric field that varies with location. No force is exerted on this charge:

A) at locations where the electric field is zero
B) at locations where the electric field strength is $1/(1.6 \times 10^{-19})$ N/C
C) if the particle is moving along a field line
D) if the particle is moving perpendicularly to a field line
E) if the field is caused by an equal amount of positive and negative charge

10. When the dipole moment of an electric dipole in a uniform electric field rotates to become more nearly aligned with the field:

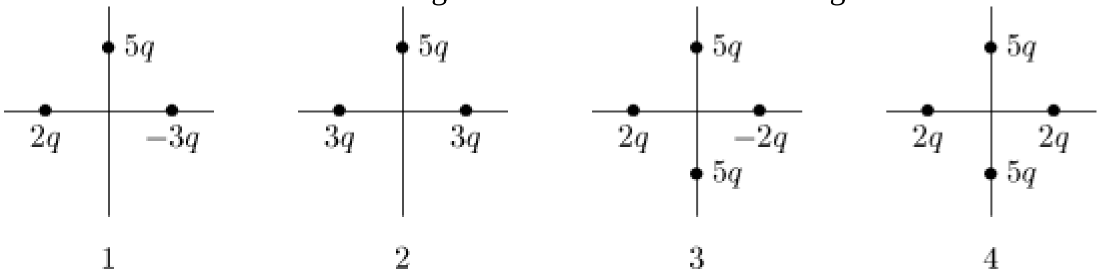
A) the field does positive work and the potential energy increases
B) the field does positive work and the potential energy decreases
C) the field does negative work and the potential energy increases
D) the field does negative work and the potential energy decreases
E) the field does no work

11. Two protons (p_1 and p_2) are on the *x* axis, as shown below. The directions of the electric field at points 1, 2, and 3, respectively, are:



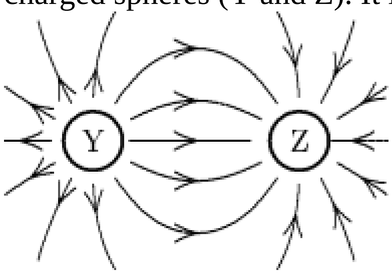
A) $\rightarrow, \leftarrow, \rightarrow$
B) $\leftarrow, \rightarrow, \leftarrow$
C) $\leftarrow, \rightarrow, \rightarrow$
D) $\leftarrow, \leftarrow, \leftarrow$
E) $\leftarrow, \leftarrow, \rightarrow$

12. The diagrams below depict four different charge distributions. The charged particles are all the same distance from the origin. The electric field at the origin:



A) is greatest for situation 1
B) is greatest for situation 3
C) is zero for situation 4
D) is downward for situation 1
E) is downward for situation 3

13. The diagram shows the electric field lines in a region of space containing two small charged spheres (Y and Z). It implies that:



A) Y is negative and Z is positive
B) the magnitude of the electric field is the same everywhere
C) the electric field is strongest midway between Y and Z
D) Y is positive and Z is negative
E) Y and Z must have the same sign

14. A possible unit for an electric field is:

A) J/(C · m)
B) J/C
C) J · C
D) J/m
E) none of these

15. An electron traveling north enters a region where the electric field is uniform and points west. The electron:

A) speeds up
B) slows down
C) veers east
D) veers west
E) continues with the same speed in the same direction

16. An electric field exerts a torque on an electric dipole only if:

A) the field is parallel to the dipole moment
B) the field is not parallel to the dipole moment
C) the field is perpendicular to the dipole moment
D) the field is not perpendicular to the dipole moment
E) the field is uniform

17. An electric field is most directly related to:

A) the momentum of a test charge
B) the kinetic energy of a test charge
C) the potential energy of a test charge
D) the force acting on a test charge
E) the charge carried by a test charge

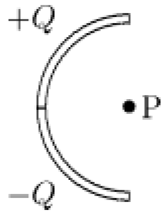
18. An isolated charged point particle produces an electric field with magnitude E at a point 2 m away. At a point 1 m from the particle the magnitude of the field is:

A) E
B) $2E$
C) $4E$
D) $E/2$
E) $E/4$

19. An isolated charged point particle produces an electric field with magnitude E at a point 2 m away from the charge. A point at which the field magnitude is $E/4$ is:

A) 1 m away from the particle
B) 0.5 m away from the particle
C) 2 m away from the particle
D) 4 m away from the particle
E) 8 m away from the particle

20. Positive charge $+Q$ is uniformly distributed on the upper half of a semicircular rod and negative charge $-Q$ is uniformly distributed on the lower half. What is the direction of the electric field at point P, the center of the semicircle?



A) $\uparrow$
B) $\downarrow$
C) $\leftarrow$
D) $\rightarrow$
E) $\nearrow$

21. Two point particles, with charges of q_1 and q_2, are placed a distance r apart. The electric field is zero at a point P between the particles on the line segment connecting them. This implies that:

A) q_1 and q_2 must have the same magnitude and sign
B) P must be midway between the particles
C) q_1 and q_2 must have the same sign but may have different magnitudes
D) q_1 and q_2 must have equal magnitudes and opposite signs
E) q_1 and q_2 must have opposite signs and may have different magnitudes

22. The magnitude of the electric field at a distance of 10 cm from an isolated point particle with a charge of 2×10^{-9} C is:

A) 1.8 N/C
B) 180 N/C
C) 18 N/C
D) 1800 N/C
E) none of these

23. An electric dipole consists of a particle with a charge of $+6 \times 10^{-6}$ C at the origin and a particle with a charge of -6×10^{-6} C on the x axis at $x = 3 \times 10^{-3}$ m. Its dipole moment is:

A) 1.8×10^{-8} C · m, in the positive x direction
B) 1.8×10^{-8} C · m, in the negative x direction
C) 0 because the net charge is 0
D) 1.8×10^{-8} C · m, in the positive y direction
E) 1.8×10^{-8} C · m, in the negative y direction

24. The magnitude of the force of a 400-N/C electric field on a point particle with a charge of 0.02 C is:

A) 8.0 N
B) 8×10^{-5} N
C) 8×10^{-3} N
D) 0.08 N
E) 2×10^{11} N

25. Two thin spherical shells, one with radius R and the other with radius $2R$, surround an isolated charged point particle. The ratio of the number of field lines through the larger sphere to the number through the smaller is:

A) 1
B) 2
C) 4
D) 1/2
E) 1/4

Answer Key

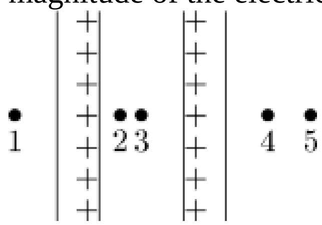
1. D
2. D
3. C
4. D
5. C
6. B
7. D
8. A
9. A
10. B
11. E
12. C
13. D
14. A
15. C
16. B
17. D
18. C
19. D
20. B
21. C
22. D
23. B
24. A
25. A

Name: ___________________________ Date: _____________

1. A point charged particle is placed at the center of a spherical Gaussian surface. The net electric flux Φ^{net} at the surface is changed if:

A) the sphere is replaced by a cube of the same volume
B) the sphere is replaced by a cube of one-tenth the volume
C) the particle is moved off center (but still inside the original sphere)
D) the particle is moved to just outside the sphere
E) a second point charged particle is placed just outside the sphere

2. Two large parallel plates carry positive charge of equal magnitude that is distributed uniformly over their inner surfaces. Rank the points 1 through 5 according to the magnitude of the electric field at the points, least to greatest.



A) 1, 2, 3, 4, 5
B) 5, 4, 3, 2, 1
C) 1, 4, and 5 tie, then 2 and 3 tie
D) 2 and 3 tie, then 1 and 4 tie, then 5
E) 2 and 3 tie, then 1, 4, and 5 tie

3. 10 C of charge are placed on a spherical conducting shell. A –3-C point charge is placed at the center of the cavity. The net charge in coulombs on the inner surface of the shell is:

A) –7
B) –3
C) 0
D) + 3
E) + 7

4. Charge Q is distributed uniformly throughout an insulating sphere of radius R. The magnitude of the electric field at a point $R/2$ from the center is:

A) $Q/4\pi \epsilon_0 R^2$
B) $Q/\pi \epsilon_0 R^2$
C) $3Q/4\pi \epsilon_0 R^2$
D) $Q/8\pi \epsilon_0 R^2$
E) none of these

5. A 5.0-μC point charge is placed at the corner of a cube. The total electric flux in $N \cdot m^2$ /C through all sides of the cube is:

A) 0
B) 7.1×10^4
C) 9.4×10^4
D) 1.4×10^5
E) 5.6×10^5

6. Charge Q is distributed uniformly throughout a spherical insulating shell. The net electric flux at the outer surface of the shell is:

A) 0
B) Q/ϵ_0
C) $2Q/\epsilon_0$
D) $Q/4\epsilon_0$
E) $Q/2\pi \epsilon_0$

7. A 3.5-cm radius hemisphere contains a total charge of 6.6×10^{-7} C. The net flux at the rounded portion of the surface is 9.8×10^4 $N \cdot m^2$ /C. The net flux at the flat base is:

A) 0
B) $+ 2.3 \times 10^4$ $N \cdot m^2$ /C
C) -2.3×10^4 $N \cdot m^2$ /C
D) -9.8×10^4 $N \cdot m^2$ /C
E) $+ 9.8 \times 10^4$ $N \cdot m^2$ /C

8. Charge is distributed uniformly along a long straight wire. The electric field 2 cm from the wire is 20 N/C. The electric field 4 cm from the wire is:

A) 120 N/C
B) 80 N/C
C) 40 N/C
D) 10 N/C
E) 5 N/C

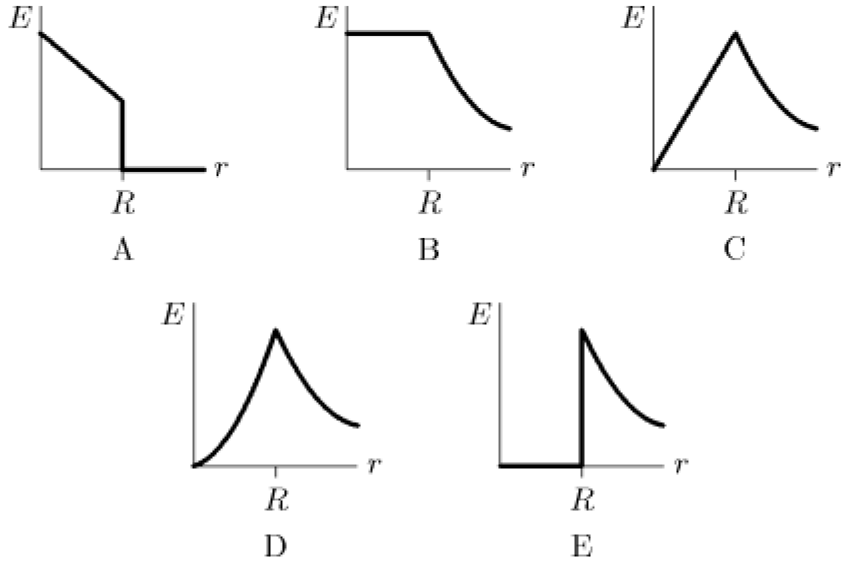
9. Positive charge Q is placed on a conducting spherical shell with inner radius R_1 and outer radius R_2. A point charge q is placed at the center of the cavity. The magnitude of the electric field at a point in the cavity, a distance r from the center, is:

A) zero
B) $Q/4\pi \in_0 R_1^2$
C) $q/4\pi \in_0 r^2$
D) $(q+Q)/4\pi \in_0 r^2$
E) $(q+Q)/4\pi \in_0 (R_1^2 - r^2)$

10. The outer surface of the cardboard center of a paper towel roll:

A) is a possible Gaussian surface
B) cannot be a Gaussian surface because it encloses no charge
C) cannot be a Gaussian surface since it is an insulator
D) is not a closed surface
E) none of the above

11. Which of the following graphs represents the magnitude of the electric field as a function of the distance from the center of a solid charged conducting sphere of radius *R*?



A) A
B) B
C) C
D) D
E) E

12. A total charge of 6.3×10^{-8} C is distributed uniformly throughout a 2.7-cm radius sphere. The volume charge density is:

A) 3.7×10^{-7} C/m^3
B) 6.9×10^{-6} C/m^3
C) 6.9×10^{-6} C/m^2
D) 2.5×10^{-4} C/m^3
E) 7.6×10^{-4} C/m^3

13. A point particle with charge *q* is placed inside the cube but not at its center. The electric flux through any one side of the cube:

A) is zero
B) is q/ϵ_0
C) is $q/4\epsilon_0$
D) is $q/6\epsilon_0$
E) cannot be computed using Gauss' law

14. When a piece of paper is held with one face perpendicular to a uniform electric field the flux through it is 25 N · m^2 /C. When the paper is turned 25º with respect to the field the flux through it is:

A) 0
B) 12 N · m^2/C
C) 21 N · m^2/C
D) 23 N · m^2/C
E) 25 N · m^2/C

15. A 30-N/C uniform electric field points perpendicularly toward the left face of a large neutral conducting sheet. The surface charge density in C/m^2 on the left and right faces, respectively, are:

A) -2.7×10^{-9} C/m^2; $+2.7 \times 10^{-9}$ C/m^2
B) $+2.7 \times 10^{-9}$ C/m^2; -2.7×10^{-9} C/m^2
C) -5.3×10^{-9} C/m^2; $+5.3 \times 10^{-9}$ C/m^2
D) $+5.3 \times 10^{-9}$ C/m^2; -5.3×10^{-9} C/m^2
E) 0; 0

16. A long line of charge with λ_ℓ charge per unit length runs along the cylindrical axis of a cylindrical conducting shell which carries a charge per unit length of λ_c. The charge per unit length on the inner and outer surfaces of the shell, respectively are:

A) λ_ℓ and λ_c
B) $-\lambda_\ell$ and $\lambda_c + \lambda_\ell$
C) $-\lambda_\ell$ and $\lambda_c - \lambda_c$
D) $\lambda_\ell + \lambda_c$ and $\lambda_c - \lambda_\ell$
E) $\lambda_\ell - \lambda_c$ and $\lambda_c + \lambda_\ell$

17. A hollow conductor is positively charged. A small uncharged metal ball is lowered by a silk thread through a small opening in the top of the conductor and allowed to touch its inner surface. After the ball is removed, it will have:

A) a positive charge
B) a negative charge
C) no appreciable charge
D) a charge whose sign depends on what part of the inner surface it touched
E) a charge whose sign depends on where the small hole is located in the conductor

18. A cylinder has a radius of 2.1 cm and a length of 8.8 cm. Total charge 6.1×10^{-7} C is distributed uniformly throughout. The volume charge density is:

A) 5.3×10^{-5} C/m^3
B) 5.3×10^{-5} C/m^2
C) 8.5×10^{-4} C/m^3
D) 5.0×10^{-3} C/m^3
E) 6.3×10^{-2} C/m^3

19. A conducting sphere of radius 0.01 m has a charge of 1.0×10^{-9} C deposited on it. The magnitude of the electric field in N/C just outside the surface of the sphere is:

A) 0
B) 450
C) 900
D) 4500
E) 90,000

20. Choose the INCORRECT statement:

A) Gauss' law can be derived from Coulomb's law
B) Gauss' law states that the net number of lines crossing any closed surface in an outward direction is proportional to the net charge enclosed within the surface
C) Coulomb's law can be derived from Gauss' law and symmetry
D) Gauss' law applies to a closed surface of any shape
E) According to Gauss' law, if a closed surface encloses no charge, then the electric field must vanish everywhere on the surface

21. A point particle with charge q is at the center of a Gaussian surface in the form of a cube. The electric flux through any one face of the cube is:

A) q/ϵ_0
B) $q/4\pi\epsilon_0$
C) $q/3\epsilon_0$
D) $q/6\epsilon_0$
E) $q/12\epsilon_0$

22. Positive charge Q is distributed uniformly throughout an insulating sphere of radius R, centered at the origin. A positive point charge Q is placed at $x = 2R$ on the x axis. The magnitude of the electric field at $x = R/2$ on the x axis is:

A) $Q/4\pi \in_0 R^2$
B) $Q/8\pi \in_0 R^2$
C) $7Q/18\pi \in_0 R^2$
D) $11Q/18\pi \in_0 R^2$
E) none of these

23. Consider Gauss' law: $\oint \vec{E} \cdot d\vec{A} = q^{\text{enc}}/\in_0$. Which of the following is true?

A) $\vec{E}$ must be the electric field due to the enclosed charge
B) If $q^{\text{enc}} = 0$, then $\vec{E} = 0$ everywhere on the Gaussian surface
C) If three particles are inside and they have charges of $+q$, $+q$, and $-2q$, then the integral is zero
D) on the surface $\vec{E}$ is everywhere parallel to $d\vec{A}$
E) If a charged particle is placed outside the surface, then it cannot affect $\vec{E}$ at any point on the surface

24. The table below gives the electric flux in $N \cdot m^2/C$ through the ends and round surfaces of four Gaussian surfaces in the form of cylinders. Rank the cylinders according to the net charge inside, from the most negative to the most positive.

	left end	right end	rounded surface
cylinder 1:	$+2 \times 10^{-9}$	$+4 \times 10^{-9}$	-6×10^{-9}
cylinder 2:	$+3 \times 10^{-9}$	-2×10^{-9}	$+6 \times 10^{-9}$
cylinder 3:	-2×10^{-9}	-5×10^{-9}	$+3 \times 10^{-9}$
cylinder 4:	$+2 \times 10^{-9}$	-5×10^{-9}	-3×10^{-9}

A) 1, 2, 3, 4
B) 4, 3, 2, 1
C) 3, 4, 2, 1
D) 3, 1, 4, 2
E) 4, 3, 1, 2

25. A spherical conducting shell has charge Q. A point charge q is placed at the center of the cavity. The charge on the inner surface of the shell and the charge on the outer surface of the shell, respectively, are:

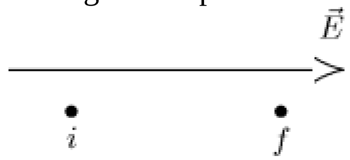
A) 0, Q
B) q, $Q - q$
C) Q, 0
D) $-q$, $Q + q$
E) $-q$, 0

Answer Key

1. D
2. E
3. D
4. D
5. E
6. B
7. C
8. D
9. C
10. D
11. E
12. E
13. E
14. D
15. A
16. B
17. C
18. D
19. C
20. E
21. D
22. C
23. C
24. E
25. D

Name: ___________________________ Date: _____________

1. An electron moves from point *i* to point *f*, in the direction of a uniform electric field. During this displacement:



A) the work done by the field is positive and the potential energy of the electron-field system increases
B) the work done by the field is negative and the potential energy of the electron-field system increases
C) the work done by the field is positive and the potential energy of the electron-field system decreases
D) the work done by the field is negative and the potential energy of the electron-field system decreases
E) the work done by the field is positive and the potential energy of the electron-field system does not change

2. The potential difference between the ends of a 2-meter stick that is parallel to a uniform electric field is 400 V. The magnitude of the electric field is:

A) zero
B) 100 V/m
C) 200 V/m
D) 400 V/m
E) 800 V/m

3. In separate experiments, four different particles each start from far away with the same speed and impinge directly on a gold nucleus. The masses and charges of the particles are
particle 1: mass m_0, charge q_0
particle 2: mass $2m_0$, charge $2q_0$
particle 3: mass $2m_0$, charge $q_0/2$
particle 4: mass $m_0/2$, charge $2q_0$
Rank the particles according to the distance of closest approach to the gold nucleus, from smallest to largest.

A) 1, 2, 3, 4
B) 4, 3, 2, 1
C) 3, 1 and 2 tie, then 4
D) 4, 1 and 2 tie, then 1
E) 1 and 2 tie, then 3, 4

4. The electric field in a region around the origin is given by $\vec{E} = C(x\,\hat{\mathrm{i}} + y\,\hat{\mathrm{j}})$, where C is a constant. The equipotential surfaces in that region are:

A) concentric cylinders with axes along the *z* axis
B) concentric cylinders with axes along the *x* axis
C) concentric spheres centered at the origin
D) planes parallel to the *xy* plane
E) planes parallel to the *yz* plane

5. If 500 J of work are required to carry a charged particle between two points with a potential difference of 20 V, the magnitude of the charge on the particle is:

A) 0.040 C
B) 12.5 C
C) 20 C
D) cannot be computed unless the path is given
E) none of these

6. In a certain region of space the electric potential increases uniformly from east to west and does not vary in any other direction. The electric field:

A) points east and varies with position
B) points east and does not vary with position
C) points west and varies with position
D) points west and does not vary with position
E) points north and does not vary with position

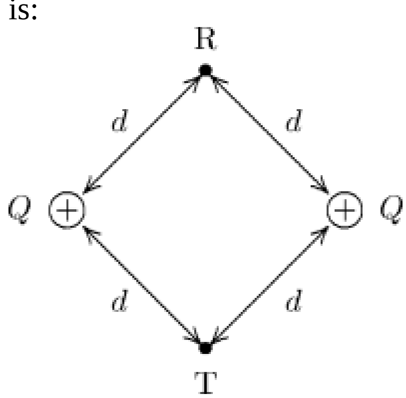
7. Choose the correct statement:

A) A proton tends to go from a region of low potential to a region of high potential
B) The potential of a negatively charged conductor must be negative
C) If $\vec{E}=0$ at a point P then V must be zero at P
D) If $V = 0$ at a point P then $\vec{E}$ must be zero at P
E) None of the above are correct

8. A 5-cm radius isolated conducting sphere is charged so its potential is + 100 V, relative to the potential far away. The charge density on its surface is:

A) $+2.2 \times 10^{-7}$ C/m^2
B) -2.2×10^{-7} C/m^2
C) $+3.5 \times 10^{-7}$ C/m^2
D) -3.5×10^{-7} C/m^2
E) $+1.8 \times 10^{-8}$ C/m^2

9. Points R and T are each a distance d from each of two particles with equal positive charges as shown. If $k = 1/4\pi\epsilon_0$, the work required to move a test charge q from R to T is:



A) 0
B) kQq/d^2
C) kQq/d
D) $kQq/(\sqrt{2}d)$
E) $kQq/(2d)$

10. Two conducting spheres are far apart. The smaller sphere carries a total charge Q. The larger sphere has a radius that is twice that of the smaller and is neutral. After the two spheres are connected by a conducting wire, the charges on the smaller and larger spheres, respectively, are:

A) $Q/2$ and $Q/2$
B) $Q/3$ and $2Q/3$
C) $2Q/3$ and $Q/3$
D) zero and Q
E) $2Q$ and $-Q$

11. A total charge of 7×10^{-8} C is uniformly distributed throughout a non-conducting sphere with a radius of 5 cm. The electric potential at the surface, relative to the potential far away, is about:

A) -1.3×10^{4} V
B) 1.3×10^{4} V
C) 7.0×10^{5} V
D) -6.3×10^{4} V
E) 0

12. During a lightning discharge, 30 C of charge move through a potential difference of 1.0×10^{8} V in 2.0×10^{-2} s. The energy released by this lightning bolt is:

A) 1.5×10^{11} J
B) 3.0×10^{9} J
C) 6.0×10^{7} J
D) 3.3×10^{6} J
E) 1500 J

13. The potential difference between two points is 100 V. If 2 C is transported from one of these points to the other, the magnitude of the work done is:

A) 200 J
B) 100 J
C) 50 J
D) 100 J
E) 2 J

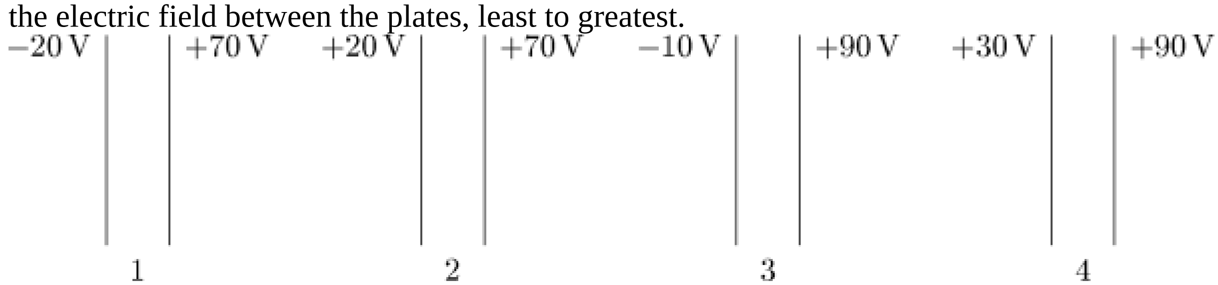
14. A 5.5×10^{-8}-C charge is fixed at the origin. A -2.3×10^{-8}-C charge is moved from x = 3.5 cm on the x axis to y = 3.5 cm on the y axis. The change in the potential energy of the two-charge system is:

A) 3.2×10^{-4} J
B) -3.2×10^{-4} J
C) 9.3×10^{-3} J
D) -9.3×10^{-3} J
E) 0

15. The work in joules required to carry a 6.0-C charge from a 5.0-V equipotential surface to a 6.0-V equipotential surface and back again to the 5.0-V surface is:

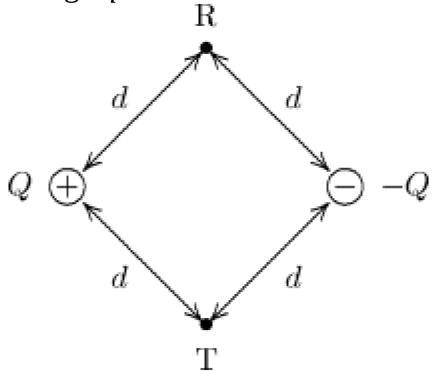
A) 0
B) 1.2×10^{-5}
C) 3.0×10^{-5}
D) 6.0×10^{-5}
E) 6.0×10^{-6}

16. The diagram shows four pairs of large parallel conducting plates. The value of the electric potential is given for each plate. Rank the pairs according to the magnitude of the electric field between the plates, least to greatest.



A) 1, 2, 3, 4
B) 4, 3, 2, 1
C) 2, 3, 1, 4
D) 2, 4, 1, 3
E) 3, 2, 4, 1

17. Points R and T are each a distance d from each of two particles with equal and opposite charges as shown. If $k = 1/4\pi\epsilon_0$, the work required to move a particle with negative charge q from R to T is:



A) 0
B) kqQ/d^2
C) kqQ/d
D) $kqQ/(\sqrt{2}d)$
E) $kQq/(2d)$

18. Equipotential surfaces associated with an electric dipole are:

A) spheres centered on the dipole
B) cylinders with axes along the dipole moment
C) planes perpendicular to the dipole moment
D) planes parallel to the dipole moment
E) none of the above

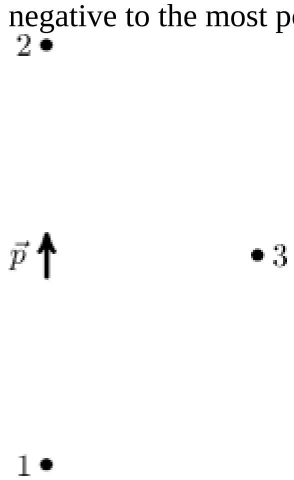
19. Positive charge is distributed uniformly throughout a non-conducting sphere. The highest electric potential occurs:

A) at the center
B) at the surface
C) halfway between the center and surface
D) just outside the surface
E) far from the sphere

20. An electron is accelerated from rest through a potential difference *V*. Its final speed is proportional to:

A) V
B) V^2
C) $\sqrt{V}$
D) $1/V$
E) $1/\sqrt{V}$

21. In the diagram, the points 1, 2, and 3 are all the same very large distance from a dipole. Rank the points according to the values of the electric potential at them, from the most negative to the most positive.



A) 1, 2, 3
B) 3, 2, 1
C) 2, 3, 1
D) 1, 3, 2
E) 1 and 2 tie, then 3

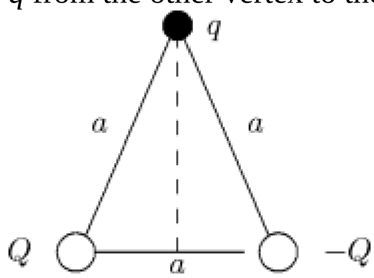
22. A conducting sphere with radius *R* is charged until the magnitude of the electric field just outside its surface is *E*. The electric potential of the sphere, relative to the potential far away, is:

A) zero
B) E/R
C) E/R^2
D) ER
E) ER^2

23. Eight identical spherical raindrops are each at a potential V, relative to the potential far away. They coalesce to make one spherical raindrop whose potential is:

A) $V/8$
B) $V/2$
C) $2V$
D) $4V$
E) $8V$

24. Two particles with charges Q and $-Q$ are fixed at the vertices of an equilateral triangle with sides of length a. If $k = 1/4\pi\epsilon_0$, the work required to move a particle with charge q from the other vertex to the center of the line joining the fixed charges is:



A) 0
B) kQq/a
C) kQq/a^2
D) $2kQq/a$
E) $\sqrt{2}kQq/a$

25. Two identical charges q are placed on the x axis, one at the origin and the other at $x = 5$ cm. A third charge $-q$ is placed on the x axis so the potential energy of the three-charge system is the same as the potential energy at infinite separation. Its x coordinate is:

A) 13 cm
B) 2.5 cm
C) 7.5 cm
D) 10 cm
E) –5 cm

Answer Key

1. B
2. E
3. C
4. A
5. B
6. B
7. E
8. E
9. A
10. B
11. B
12. B
13. A
14. E
15. A
16. D
17. A
18. E
19. A
20. C
21. D
22. D
23. D
24. A
25. A

Name: ___________________________ Date: _____________

1. The current density is the same in two wires. Wire A has twice the free-electron concentration of wire B. The magnitude of the average velocity of electrons in A is:

A) twice that of electrons in B
B) four times that of electrons in B
C) half that of electrons in B
D) one-fourth that of electrons in B
E) the same as that of electrons in B

2. Copper contains 8.4×10^{28} free electrons/m^3. A copper wire of cross-sectional area 7.4×10^{-7} m^2 carries a current of 1 A. The magnitude of the average electron velocity is approximately:

A) 3×10^8 m/s
B) 10^3 m/s
C) 1 m/s
D) 10^{-4} m/s
E) 10^{-23} m/s

3. For an ohmic resistor, resistance is the proportionality constant for:

A) potential difference and electric field
B) current and electric field
C) current and length
D) current and cross-sectional area
E) current and potential difference

4. A certain wire has resistance R. Another wire, of the same material, has half the length and half the diameter of the first wire. The resistance of the second wire is:

A) $R/4$
B) $R/2$
C) R
D) $2R$
E) $4R$

5. For an ohmic substance the resistivity is the proportionality constant for:

A) current and potential difference
B) current and electric field
C) current density and potential difference
D) current density and electric field
E) potential difference and electric field

6. A car battery is rated at 80 A · h. An ampere-hour is a unit of:

A) power
B) energy
C) current
D) charge
E) force

7. The current is zero in a conductor when no potential difference is applied because:

A) the electrons are not moving
B) the electrons are not moving fast enough
C) for every electron with a given velocity there is another with a velocity of equal magnitude and opposite direction.
D) equal numbers of electrons and protons are moving together
E) otherwise Ohm's law would not be valid

8. Two wires are made of the same material and have the same length but different radii. They are joined end-to-end and a potential difference is maintained across the combination. Of the following the quantity that is the same for both wires is:

A) potential difference
B) current
C) current density
D) electric field
E) average conduction electron velocity

9. Two wires made of different materials have the same uniform current density. They carry the same current only if:

A) their lengths are the same
B) their cross-sectional areas are the same
C) both their lengths and cross-sectional areas are the same
D) the potential differences across them are the same
E) the electric fields in them are the same

10. A coulomb is the same as:

A) ampere/second
B) (1/2) ampere · second^2
C) ampere/meter^2
D) ampere · second
E) newton · meter^2

11. A flat iron is marked “120 V, 600 W”. In normal use, the current in it is:

A) 2 A
B) 4 A
C) 5 A
D) 7.2 A
E) 0.2 A

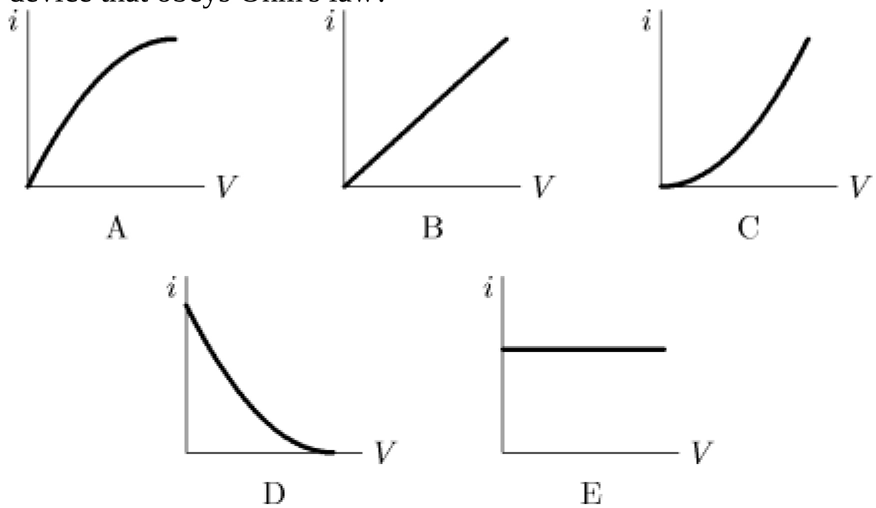
12. A certain sample carries a current of 4 A when the potential difference is 2 V and a current of 10 A when the potential difference is 4 V. This sample:

A) obeys Ohm's law
B) has a resistance of 0.5 Ω at 1 V
C) has a resistance of 2.5 Ω at 1 V
D) has a resistance of 2.5 Ω at 2 V
E) does not have a resistance

13. Of the following, the copper conductor that has the least resistance is:

A) thin, long and hot
B) thick, short and cool
C) thick, long and hot
D) thin, short and cool
E) thin, short and hot

14. Which of the following graphs best represents the current-voltage relationship for a device that obeys Ohm's law?



A) A
B) B
C) C
D) D
E) E

15. A student kept her 60-watt, 120-volt study lamp turned on from 2:00 PM until 2:00 AM. The charge that went through it was

A) 150 C
B) 3,600 C
C) 7,200 C
D) 18,000 C
E) 21,600 C

16. The rate at which electrical energy is used may be measured in the unit:

A) watt/second
B) watt · second
C) watt
D) joule · second
E) kilowatt · hour

17. You wish to triple the rate of electrical energy dissipation in a heating device. To do this you could triple:

A) the potential difference keeping the resistance the same
B) the current keeping the resistance the same
C) the resistance keeping the potential difference the same
D) the resistance keeping the current the same
E) both the potential difference and current

18. Conductivity is:

A) the same as resistivity, it is just more convenient to use for good conductors
B) expressed in Ω^{-1}
C) equal to 1/resistance
D) expressed in $(\Omega \cdot \text{m})^{-1}$
E) not a meaningful quantity for an insulator

19. It is better to send 10,000 kW of electric power long distances at 10,000 V rather than at 220 V because:

A) there is less heating in the transmission wires
B) the resistance of the wires is less at high voltages
C) more current is transmitted at high voltages
D) the insulation is more effective at high voltages
E) the iR drop along the wires is greater at high voltage

20. Current has units:

A) kilowatt · hour
B) coulomb/second
C) coulomb
D) volt
E) ohm

21. A 60-watt light bulb carries a current of 0.5 A. The total charge passing through it in one hour is:

A) 120 C
B) 3600 C
C) 3000 C
D) 2400 C
E) 1800 C

22. If $\vec{J}$ is the current density and $d\vec{A}$ is a vector element of area then the integral $\int \vec{J} \cdot d\vec{A}$ over an area represents:

A) the electric flux at the area
B) the average current density at the position of the area
C) the resistance of the area
D) the resistivity of the area
E) the current through the area

23. A cylindrical copper rod has resistance *R*. It is reformed to twice its original length with no change of volume. Its new resistance is:

A) R
B) $2R$
C) $4R$
D) $8R$
E) $R/2$

24. The mechanical equivalent of heat is 1 cal = 4.18 J. The specific heat of water is 1 cal/g · K. An electric immersion water heater, rated at 400 W, should heat a kilogram of water from 10º C to 30º C in about:

A) 3.5 min
B) 1 min
C) 15 min
D) 45 min
E) 15 s

25. Current has units:

- **A)** kilowatt · hour
- **B)** ampere
- **C)** coulomb
- **D)** volt
- **E)** ohm

Answer Key

1. C
2. D
3. E
4. D
5. D
6. D
7. C
8. B
9. B
10. D
11. C
12. B
13. B
14. B
15. E
16. C
17. D
18. D
19. A
20. B
21. E
22. E
23. C
24. A
25. B

Name: ___________________________ Date: _____________

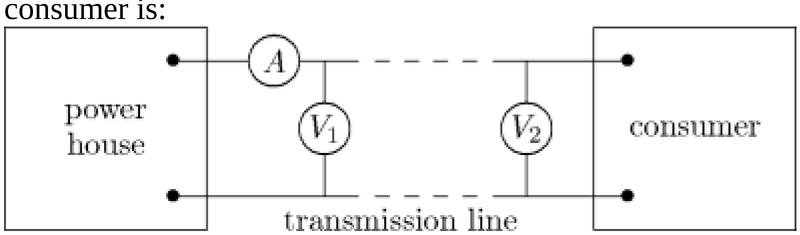
1. By using only two resistors, R_1 and R_2, a student is able to obtain resistances of 3 Ω, 4 Ω, 12 Ω, and 16 Ω. The values of R_1 and R_2 (in ohms) are:

A) 3, 4
B) 2, 12
C) 3, 16
D) 4, 12
E) 4, 16

2. Four 20-Ω resistors are connected in parallel and the combination is connected to a 20-V emf device. The current in any one of the resistors is:

A) 0.25 A
B) 1.0 A
C) 4.0 A
D) 5.0 A
E) 100 A

3. In the figure, voltmeter V_1 reads 600 V, voltmeter V_2 reads 580 V, and ammeter A reads 100 A. The power wasted in the transmission line connecting the power house to the consumer is:



A) 1 kW
B) 2 kW
C) 58 kW
D) 59 kW
E) 60 kW

4. A series circuit consists of a battery with internal resistance r and an external resistor R. If these two resistances are equal ($r = R$) then the thermal energy generated per unit time by the internal resistance r is:

A) the same as by R
B) half that by R
C) twice that by R
D) one-third that by R
E) unknown unless the emf is given

5. A certain ammeter has an internal resistance of 1 Ω and a range from 0 to 50 mA. To make its range from 0 to 5 A, use:

A) a series resistance of 99 Ω
B) an extremely large (say 10^6 Ω) series resistance
C) a resistance of 99 Ω in parallel
D) a resistance of 1/99 Ω in parallel
E) a resistance of 1/1000 Ω in parallel

6. A 120-V power line is protected by a 15-A fuse. What is the maximum number of "120 V, 500 W" light bulbs that can be operated at full brightness from this line?

A) 1
B) 2
C) 3
D) 4
E) 5

7. Two identical batteries, each with an emf of 18 V and an internal resistance of 1 Ω, are wired in parallel by connecting their positive terminals together and connecting their negative terminals together. The combination is then wired across a 4-Ω resistor. The potential difference across the 4-Ω resistor is:

A) 4.0 V
B) 8.0 V
C) 14 V
D) 16 V
E) 29 V

8. The resistance of resistor 1 is twice the resistance of resistor 2. The two are connected in parallel and a potential difference is maintained across the combination. Then:

A) the current in 1 is twice that in 2
B) the current in 1 is half that in 2
C) the potential difference across 1 is twice that across 2
D) the potential difference across 1 is half that across 2
E) none of the above are true

9. The emf of a battery is equal to its terminal potential difference:

A) under all conditions
B) only when the battery is being charged
C) only when a large current is in the battery
D) only when there is no current in the battery
E) under no conditions

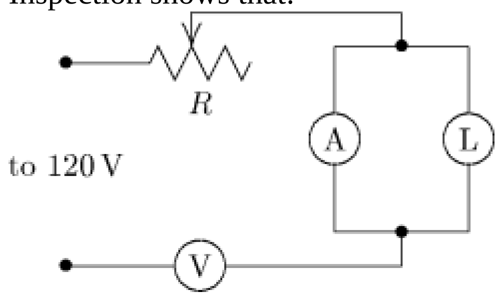
10. The terminal potential difference of a battery is less than its emf:

A) under all conditions
B) only when the battery is being charged
C) only when the battery is being discharged
D) only when there is no current in the battery
E) under no conditions

11. Resistor 1 has twice the resistance of resistor 2. The two are connected in series and a potential difference is maintained across the combination. The rate of thermal energy generation in 1 is:

A) the same as that in 2
B) twice that in 2
C) half that in 2
D) four times that in 2
E) one-fourth that in 2

12. The circuit shown was wired for the purpose of measuring the resistance of the lamp L. Inspection shows that:



A) voltmeter V and rheostat R should be interchanged
B) the circuit is satisfactory
C) the ammeter A should be in parallel with R, not L
D) the meters, V and A, should be interchanged
E) L and V should be interchanged

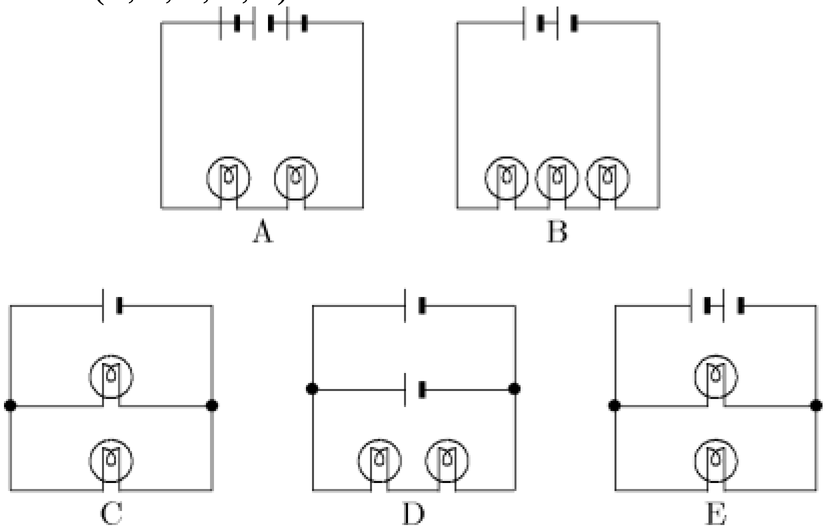
13. Four 20-Ω resistors are connected in series and the combination is connected to a 20-V emf device. The potential difference across any one of the resistors is:

A) 1 V
B) 4 V
C) 5 V
D) 20 V
E) 80 V

14. Four 20-Ω resistors are connected in parallel and the combination is connected to a 20-V emf device. The current in the device is:

A) 0.25 A
B) 1.0 A
C) 4.0 A
D) 5.0 A
E) 100 A

15. In the diagrams, all light bulbs are identical and all emf devices are identical. In which circuit (A, B, C, D, E) will the bulbs be dimmest?



A) A
B) B
C) C
D) D
E) E

16. Two wires made of the same material have the same lengths but different diameters. They are connected in parallel to a battery. The quantity that is NOT the same for the wires is:

A) the end-to-end potential difference
B) the current
C) the current density
D) the electric field
E) the electron drift velocity

17. A battery is connected across a parallel combination of two identical resistors. If the potential difference across the terminals is ΔV_B and the current in the battery is i, then:

A) the potential difference across each resistor is ΔV_B and the current in each resistor is i
B) the potential difference across each resistor is $(\Delta V_B)/2$ and the current in each resistor is $i/2$
C) the potential difference across each resistor is ΔV_B and the current in each resistor is $i/2$
D) the potential difference across each resistor is $(\Delta V_B)/2$ and the current in each resistor is i
E) none of the above are true

18. A 3-Ω and a 1.5-Ω resistor are wired in parallel and the combination is wired in series to a 4-Ω resistor and a 10-V emf device. The potential difference across the 3-Ω resistor is:

A) 2.0 V
B) 6.0 V
C) 8.0 V
D) 10 V
E) 12 V

19. Resistor 1 has twice the resistance of resistor 2. They are connected in parallel to a battery. The ratio of the thermal energy generation rate in 1 to that in 2 is:

A) 1 : 4
B) 1 : 2
C) 1 : 1
D) 2 : 1
E) 4 : 1

20. A battery with an emf of 24 V is connected to a 6-Ω resistor. As a result, current of 3 A exists in the resistor. The terminal potential difference of the battery is:

A) 0
B) 6 V
C) 12 V
D) 18 V
E) 24 V

21. Nine identical wires, each of diameter *d* and length *L*, are connected in parallel. The combination has the same resistance as a single similar wire of length *L* but whose diameter is:

A) 3*d*
B) 9*d*
C) *d*/3
D) *d*/9
E) *d*/81

22. A 3-Ω and a 1.5-Ω resistor are wired in parallel and the combination is wired in series to a 4-Ω resistor and a 10-V emf device. The current in the 3-Ω resistor is:

A) 0.33 A
B) 0.67 A
C) 2.0 A
D) 3.3 A
E) 6.7 A

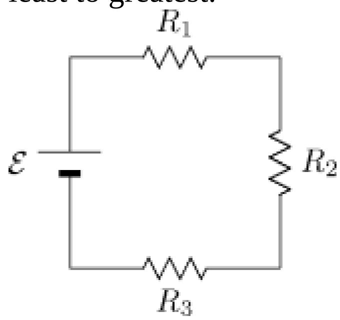
23. In the diagram, the current in the 3-Ω resistor is 4 A. The potential difference between points 1 and 2 is:

A) 0.75 V
B) 0.8 V
C) 1.25 V
D) 12 V
E) 20 V

24. Four 20-Ω resistors are connected in series and the combination is connected to a 20-V emf device. The current in any one of the resistors is:

A) 0.25 A
B) 1.0 A
C) 4.0 A
D) 5.0 A
E) 100 A

25. In the diagram $R_1 > R_2 > R_3$. Rank the three resistors according to the current in them, least to greatest.



A) 1, 2, 3
B) 3, 2, 1
C) 1, 3, 2
D) 3, 1, 3
E) All are the same

Answer Key

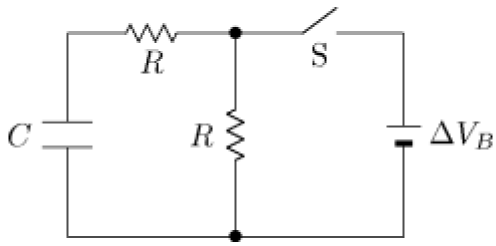
1. D
2. B
3. B
4. A
5. D
6. C
7. D
8. B
9. D
10. C
11. B
12. D
13. C
14. C
15. D
16. B
17. C
18. A
19. B
20. D
21. A
22. B
23. E
24. A
25. E

Name: ____________________________ Date: ______________

1. A 20-F capacitor is charged to 200 V. Its stored energy is:

A) 4000 J
B) 4 J
C) 0.4 J
D) 2000 J
E) 0.1 J

2. In the circuit shown, both resistors have the same value *R*. Suppose switch S is initially closed. When it is then opened, the circuit has a time constant τ_a. Conversely, suppose S is initially open. When it is then closed, the circuit has a time constant τ_b. The ratio τ_a/τ_b is:

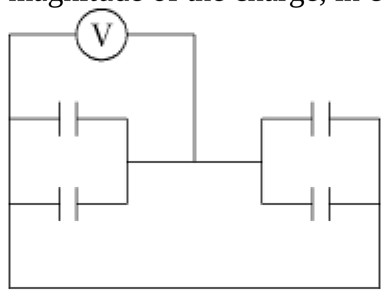


A) 1
B) 2
C) 0.5
D) 0.667
E) 1.5

3. Two parallel-plate capacitors with the same plate area but different capacitance are connected in parallel to a battery. Both capacitors are filled with air. The quantity that is the same for both capacitors when they are fully charged is:

A) potential difference
B) energy density
C) electric field between the plates
D) charge on the positive plate
E) plate separation

4. Each of the four capacitors shown is 500 μF. The voltmeter reads 1000 V. The magnitude of the charge, in coulombs, on each capacitor plate is:



A) 0.2
B) 0.5
C) 20
D) 50
E) none of these

5. Capacitors C_1 and C_2 are connected in series. The equivalent capacitance is given by:

A) $C_1C_2/(C_1 + C_2)$
B) $(C_1 + C_2)/C_1C_2$
C) $1/(C_1 + C_2)$
D) C_1/C_2
E) $C_1 + C_2$

6. Two capacitors are identical except that one is filled with air and the other with oil. Both capacitors carry the same magnitude charge on their plates. The ratio of the electric fields E_{air}/E_{oil} is:

A) between 0 and 1
B) 0
C) 1
D) between 1 and infinity
E) infinite

7. A parallel-plate capacitor has a plate area of 0.3 m^2 and a plate separation of 0.1 mm. If the charge on each plate has a magnitude of 5×10^{-6} C then the force exerted by one plate on the other has a magnitude of about:

A) 0
B) 5 N
C) 9 N
D) 1×10^4 N
E) 9×10^5 N

8. If the plate area of an isolated charged parallel-plate capacitor is doubled:

A) the electric field is doubled
B) the potential difference is halved
C) the charge on each plate is halved
D) the surface charge density on each plate is doubled
E) none of the above

9. An initially uncharged capacitor C is connected in series with resistor R. This combination is then connected to a battery with a potential difference ΔV_B. Sufficient time elapses so that a steady state is reached. Which of the following statements is NOT true?

A) The time constant is independent of ΔV_B
B) The final charge on the positive plate of C is independent of R
C) The total thermal energy generated by R is independent of R
D) The total thermal energy generated by R is independent of ΔV_B
E) The initial current (just after the battery was connected) is independent of C

10. In the capacitor discharge formula $q = q_0 e^{-t/RC}$ the symbol t represents:

A) the time constant
B) the time it takes for C to lose the fraction 1/e of its initial charge
C) the time it takes for C to lose the fraction (1–1/e) of its initial charge
D) the time it takes for C to lose essentially all of its initial charge
E) none of the above

11. If both the plate area and the plate separation of a parallel-plate capacitor are doubled, the capacitance is:

A) doubled
B) halved
C) unchanged
D) tripled
E) quadrupled

12. A 2-μF and a 1-μF capacitor are connected in series and charged from a battery. They store charges P and Q, respectively, on their positive plates. When disconnected and charged separately using the same battery, they have charges R and S, respectively, on their positive plates. Then:

A) $R > S > Q = P$
B) $P > Q > R = S$
C) $R > P = Q > S$
D) $R = P > S = Q$
E) $R > P > S = Q$

13. A battery is used to charge a parallel-plate capacitor, after which it is disconnected. Then the plates are pulled apart to twice their original separation. This process will double the:

A) capacitance
B) surface charge density on each plate
C) stored energy
D) electric field between the two places
E) charge on each plate

14. A charged capacitor stores 10 C at 40 V. Its stored energy is:

A) 400 J
B) 4 J
C) 0.2 J
D) 2.5 J
E) 200 J

15. The plate areas and plate separations of five parallel plate capacitors are
capacitor 1: area A_0, separation d_0
capacitor 2: area $2A_0$, separation $2d_0$
capacitor 3: area $2A_0$, separation $d_0/2$
capacitor 4: area $A_0/2$, separation $2d_0$
capacitor 5: area A_0, separation $d_0/2$
Rank these according to their capacitances, least to greatest.

A) 1, 2, 3, 4, 5
B) 5, 4, 3, 2, 1
C) 5, 3 and 4 tie, then 1, 2
D) 4, 1 and 2 tie, then 5, 3
E) 3, 5, 1 and 2 tie, 1, 4

16. The capacitance of a single isolated spherical conductor with radius R is proportional to:

A) R
B) R^2
C) $1/R$
D) $1/R^2$
E) none of these

17. The time constant RC has units of:

A) second/farad
B) second/ohm
C) 1/second
D) second/watt
E) none of these

18. To charge a 1-F capacitor with 2 C requires a potential difference of:

A) 2 V
B) 0.2 V
C) 5 V
D) 0.5 V
E) none of these

19. Capacitors 1 and 2 are connected in series and a potential difference is applied to the combination. If the capacitor that is equivalent to the combination has the same potential difference, then the charge on the positive plate of the equivalent capacitor is the same as:

A) the charge on the positive plate of capacitor 1
B) the sum of the charges on the positive plates of the two capacitors
C) the difference of the charges on the positive plates of the two capacitors
D) the product of the charges on the positive plates of the two capacitors
E) none of the above

20. Two parallel-plate capacitors with different plate separation but the same capacitance are connected in series to a battery. Both capacitors are filled with air. The quantity that is NOT the same for both capacitors when they are fully charged is:

A) potential difference
B) stored energy
C) electric field between the plates
D) charge on the positive plate
E) dielectric constant

21. The capacitance of a spherical capacitor with inner radius *a* and outer radius *b* is proportional to:

A) a/b
B) $b - a$
C) $b^2 - a^2$
D) $ab/(b - a)$
E) $ab/(b^2 - a^2)$

22. If the charge on a parallel-plate capacitor is doubled:

A) the capacitance is halved
B) the capacitance is doubled
C) the electric field is halved
D) the electric field is doubled
E) the surface charge density is not changed on either plate

23. Capacitors C_1 and C_2 are connected in parallel. The equivalent capacitance is given by:

A) $C_1C_2/(C_1 + C_2)$
B) $(C_1 + C_2)/C_1C_2$
C) $1/(C_1 + C_2)$
D) C_1/C_2
E) $C_1 + C_2$

24. A parallel-plate, air-filled capacitor is charged by a battery, after which the battery is disconnected. A slab of glass dielectric is then slowly inserted between the plates. As it is being inserted:

A) a force repels the glass out of the capacitor
B) a force attracts the glass into the capacitor
C) no force acts on the glass
D) a net charge appears on the glass
E) the glass makes the plates repel each other

25. Two identical capacitors, each with capacitance C, are connected in parallel and the combination is connected in series to a third identical capacitor. The equivalent capacitance of this arrangement is:

A) $2C/3$
B) C
C) $3C/2$
D) $2C$
E) $3C$

Answer Key

1. C
2. B
3. A
4. B
5. A
6. D
7. B
8. B
9. C
10. E
11. C
12. A
13. C
14. E
15. D
16. A
17. E
18. A
19. A
20. C
21. D
22. D
23. E
24. B
25. A

Name: ___________________________ Date: _____________

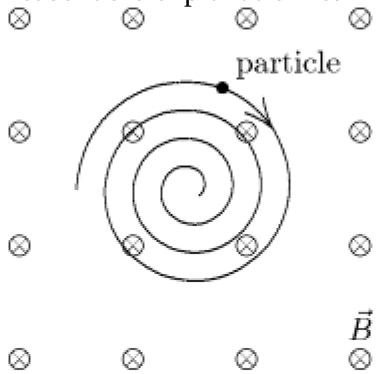
1. A loop of current-carrying wire has a magnetic dipole moment of 5×10^{-4} A · m^2. The moment initially is aligned with a 0.5-T magnetic field. To rotate the loop so its dipole moment is perpendicular to the field and hold it in that orientation, you must do work of:

A) 0
B) 2.5×10^{-4} J
C) -2.5×10^{-4} J
D) 1.0×10^{-3} J
E) -1.0×10^{-3} J

2. An electron is launched with velocity $\vec{v}$ in a uniform magnetic field $\vec{B}$. The angle θ between $\vec{v}$ and $\vec{B}$ is between 0 and 90º. As a result, the electron follows a helix, its velocity vector $\vec{v}$ returning to its initial value in a time interval of:

A) $2\pi m/eB$
B) $2\pi mv/e$B
C) $2\pi mv \sin \theta/eB$
D) $2\pi mv \cos \theta/eB$
E) none of these

3. A uniform magnetic field is directed into the page. A charged particle, moving in the plane of the page, follows a clockwise spiral of decreasing radius as shown. A reasonable explanation is:



A) the charge is positive and slowing down
B) the charge is negative and slowing down
C) the charge is positive and speeding up
D) the charge is negative and speeding up
E) none of the above

4. The units of magnetic dipole moment are:

A) ampere
B) ampere · meter
C) ampere · meter^2
D) ampere/meter
E) ampere/meter^2

5. A uniform magnetic field is in the positive *z* direction. A positively charged particle is moving in the positive *x* direction through the field. The net force on the particle can be made zero by applying an electric field in what direction?

A) Positive *y*
B) Negative *y*
C) Positive *x*
D) Negative *x*
E) Positive *z*

6. A current is clockwise around the outside edge of this page and a uniform magnetic field is directed parallel to the page, from left to right. If the magnetic force is the only force acting on the page, the page will turn so the right edge:

A) moves toward you
B) moves away from you
C) moves to your right
D) moves to your left
E) does not move

7. A charged particle is projected into a region of uniform and parallel electric and magnetic fields. The force on the particle is:

A) zero
B) at some angle $< 90^{o}$ with the field lines
C) along the field lines
D) perpendicular to the field lines
E) unknown (need to know the sign of the charge)

8. The magnetic dipole moment of a current-carrying loop of wire is in the positive z direction. If a uniform magnetic field is in the positive x direction the magnetic torque on the loop is:

A) 0
B) in the positive y direction
C) in the negative y direction
D) in the positive z direction
E) in the negative z direction

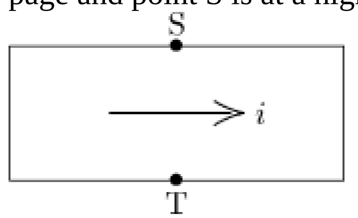
9. An electron travels due north through a vacuum in a region of uniform magnetic field $\vec{B}$ that is also directed due north. It will:

A) be unaffected by the field
B) speed up
C) slow down
D) follow a right-handed corkscrew path
E) follow a left-handed corkscrew path

10. A proton (charge e), traveling perpendicular to a magnetic field, experiences the same force as an alpha particle (charge $2e$) which is also traveling perpendicular to the same field. The ratio of their speeds, $v_{\text{proton}}/v_{\text{alpha}}$, is:

A) 0.5
B) 1
C) 2
D) 4
E) 8

11. The current is from left to right in the conductor shown. The magnetic field is into the page and point S is at a higher potential than point T. The charge carriers are:

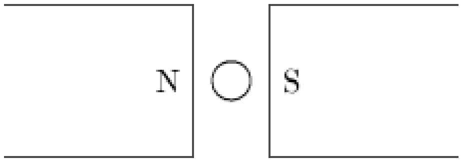


A) positive
B) negative
C) neutral
D) absent
E) moving near the speed of light

12. An electron is moving north in a region where the magnetic field is south. The magnetic force exerted on the electron is:

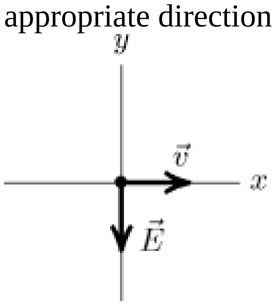
A) zero
B) up
C) down
D) east
E) west

13. The diagram shows a straight wire carrying a flow of electrons into the page. The wire is between the poles of a permanent magnet. The direction of the magnetic force exerted on the wire is:



A) ↑
B) ↓
C) ←
D) →
E) into the page

14. An electron is traveling in the positive *x* direction. A uniform electric field $\vec{E}$ is in the negative *y* direction. If a uniform magnetic field with the appropriate magnitude and direction also exists in the region, the total force on the electron will be zero. The appropriate direction for the magnetic field is:



A) the positive *y* direction
B) the negative *y* direction
C) into the page
D) out of the page
E) the negative *x* direction

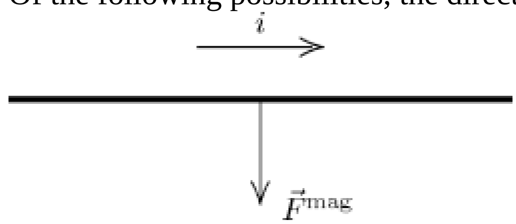
15. A magnetic field CANNOT:

A) exert a force on a charged particle
B) change the velocity of a charged particle
C) change the momentum of a charged particle
D) change the kinetic energy of a charged particle
E) change the trajectory of a charged particle

16. An electron (charge = -1.6×10^{-19} C) is moving at 3×10^5 m/s in the positive x direction. A magnetic field of 0.8 T is in the positive z direction. The magnetic force on the electron is:

A) 0
B) 4×10^{-14} N, in the positive z direction
C) 4×10^{-14} N, in the negative z direction
D) 4×10^{-14} N, in the positive y direction
E) 4×10^{-14} N, in the negative y direction

17. The diagram shows a straight wire carrying current i in a uniform magnetic field. The magnetic force on the wire is indicated by an arrow but the magnetic field is not shown. Of the following possibilities, the direction of the magnetic field is:

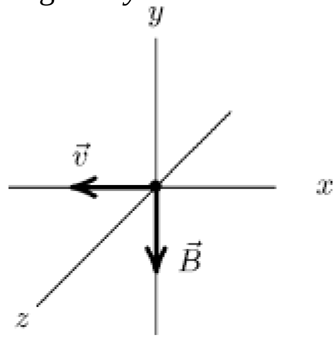


A) opposite the direction of the current
B) opposite the direction of $\vec{F}$
C) in the direction of $\vec{F}$
D) into the page
E) out of the page

18. A magnetic field exerts a force on a charged particle:

A) always
B) never
C) if the particle is moving across the field lines
D) if the particle is moving along the field lines
E) if the particle is at rest

19. An electron moves in the negative *x* direction, through a uniform magnetic field in the negative *y* direction. The magnetic force on the electron is:

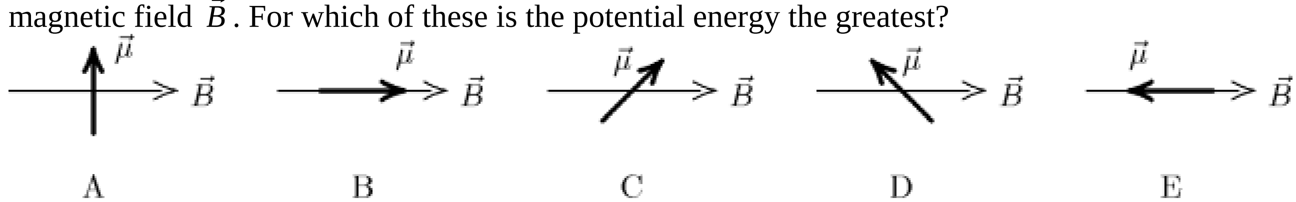


A) in the negative *x* direction
B) in the positive *y* direction
C) in the negative *y* direction
D) in the positive *z* direction
E) in the negative *z* direction

20. An ion with a charge of $+3.2 \times 10^{-19}$ C is in a region where a uniform electric field of magnitude 5×10^4 V/m is perpendicular to a uniform magnetic field of magnitude 0.8 T. If its acceleration is zero then its speed must be:

A) 0
B) 1.6×10^4 m/s
C) 4.0×10^4 m/s
D) 6.3×10^4 m/s
E) any value but 0

21. The diagrams show five possible orientations of a magnetic dipole $\vec{\mu}$ in a uniform magnetic field $\vec{B}$. For which of these is the potential energy the greatest?



A) A
B) B
C) C
D) D
E) E

22. An electron and a proton are both initially moving with the same speed and in the same direction at 90º to the same uniform magnetic field. They experience magnetic forces, which are initially:

A) identical
B) equal in magnitude but opposite in direction
C) in the same direction and differing in magnitude by a factor of 1840
D) in opposite directions and differing in magnitude by a factor of 1840
E) equal in magnitude but perpendicular to each other.

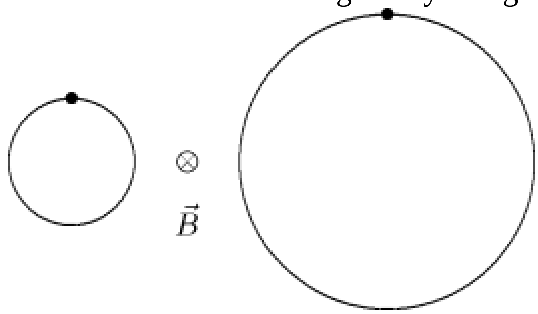
23. The magnetic force on a charged particle is in the direction of its velocity if:

A) it is moving in the direction of the field
B) it is moving opposite to the direction of the field
C) it is moving perpendicular to the field
D) it is moving in some other direction
E) never

24. The magnetic torque exerted on a flat current-carrying loop of wire by a uniform magnetic field $\vec{B}$ is:

A) maximum when the plane of the loop is perpendicular to $\vec{B}$
B) maximum when the plane of the loop is parallel to $\vec{B}$
C) dependent on the shape of the loop for a fixed loop area
D) independent of the orientation of the loop
E) such as to rotate the loop around the magnetic field lines

25. An electron and a proton each travel with equal speeds around circular orbits in the same uniform magnetic field, as shown in the diagram (not to scale). The field is into the page on the diagram. Because the electron is less massive than the proton and because the electron is negatively charged and the proton is positively charged:



A) the electron travels clockwise around the smaller circle and the proton travels counterclockwise around the larger circle
B) the electron travels counterclockwise around the smaller circle and the proton travels clockwise around the larger circle
C) the electron travels clockwise around the larger circle and the proton travels counterclockwise around the smaller circle
D) the electron travels counterclockwise around the larger circle and the proton travels clockwise around the smaller circle
E) the electron travels counterclockwise around the smaller circle and the proton travels counterclockwise around the larger circle

Answer Key

1. B
2. A
3. B
4. C
5. B
6. A
7. B
8. B
9. A
10. C
11. A
12. A
13. A
14. C
15. D
16. D
17. E
18. C
19. E
20. D
21. E
22. B
23. E
24. B
25. A

Name: ___________________________ Date: _____________

___ **1.** A wire carrying a large current i from east to west is placed over an ordinary magnetic compass. The end of the compass needle marked "N":

A) points north
B) points south
C) points east
D) points west
E) continually rotates like an electric motor

___ **2.** Suitable units for the magnetic permeability constant μ_0 are:

A) tesla
B) newton/ampere^2
C) weber/meter
D) kilogram · ampere/meter
E) tesla · meter/ampere

___ **3.** Two long straight wires enter a room through a door. One carries a current of 3.0 A into the room while the other carries a current of 5.0 A out. The magnitude of the path integral $\oint \vec{B} \cdot d\vec{s}$ around the door frame is:

A) 2.5×10^{-6} T · m
B) 3.8×10^{-6} T · m
C) 6.3×10^{-6} T · m
D) 1.0×10^{-5} T · m
E) none of these

___ **4.** Two long straight wires are parallel and carry current in opposite directions. The currents are 8.0 and 12 A and the wires are separated by 0.40 cm. The magnetic field at a point midway between the wires is:

A) 0 **B)** 4.0×10^{-4} T **C)** 8.0×10^{-4} T **D)** 12×10^{-4} T **E)** 20×10^{-4} T

___ **5.** A coulomb of charge is:

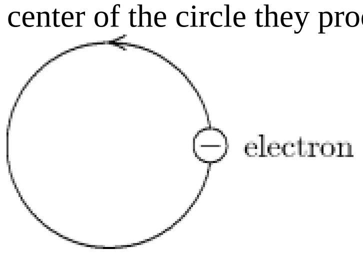
A) one ampere per second
B) the quantity of charge that will exert a force of 1 N on a similar charge at a distance of 1 m
C) the amount of current in each of two long parallel wires, separated by 1 m, that produces a force of 2×10^{-7} N/m
D) the amount of charge that flows past a point in one second when the current is 1 A
E) an abbreviation for a certain combination of kilogram, meter and second

___ **6.** A constant current is sent through a helical coil. The coil:
A) tends to get shorter
B) tends to get longer
C) tends to rotate about its axis
D) produces zero magnetic field at its center
E) none of the above

___ **7.** A long straight cylindrical shell has inner radius R_i and outer radius R_o. It carries current i, uniformly distributed over its cross section. A wire is parallel to the cylinder axis, in the hollow region ($r < R_i$). The magnetic field is zero everywhere outside the shell ($r > R_o$). We conclude that the wire:
A) is on the cylinder axis and carries current i in the same direction as the current in the shell
B) may be anywhere in the hollow region but must be carrying current i in the direction opposite to that of the current in the shell
C) may be anywhere in the hollow region but must be carrying current i in the same direction as the current in the shell
D) is on the cylinder axis and carries current i in the direction opposite to that of the current in the shell
E) does not carry any current

___ **8.** A long straight wire carrying a 3.0 A current enters a room through a window 1.5 m high and 1.0 m wide. The path integral $\oint \vec{B} \cdot d\vec{s}$ around the window frame has the value:
A) 0.20 T · m
B) 2.5×10^{-7} T · m
C) 3.0×10^{-7} T · m
D) 3.8×10^{-6} T · m
E) none of these

___ **9.** Electrons are going around a circle in a counterclockwise direction as shown. At the center of the circle they produce a magnetic field that is:



A) into the page **B)** out of the page **C)** to the left **D)** to the right **E)** zero

___ **10.** Lines of the magnetic field produced by a long straight wire carrying a current are:
A) in the direction of the current
B) opposite to the direction of the current
C) radially outward from the wire
D) radially inward toward the wire
E) circles that are concentric with the wire

___ **11.** In Ampere's law, $\oint \vec{B}\cdot d\vec{s} = \mu_0 i^{\text{enc}}$, the symbol $d\vec{s}$ is:
A) an infinitesimal piece of the wire that carries current i
B) in the direction of $\vec{B}$
C) perpendicular to $\vec{B}$
D) a vector whose magnitude is the length of the wire that carries current i^{enc}
E) none of the above

___ **12.** If the magnetic field $\vec{B}$ is uniform over the area bounded by a circle with radius R, the net current through the circle is:
A) 0 **B)** $2\pi RB/\mu_0$ **C)** $\pi R^2B/\mu_0$ **D)** $RB/2\mu_0$ **E)** $2RB/\mu_0$

___ **13.** In Ampere's law, $\oint \vec{B}\cdot d\vec{s} = \mu_0 i^{\text{enc}}$, the direction of the integration around the path:
A) must be clockwise
B) must be counterclockwise
C) must be such as to follow the magnetic field lines
D) must be along the wire in the direction of the current
E) none of the above

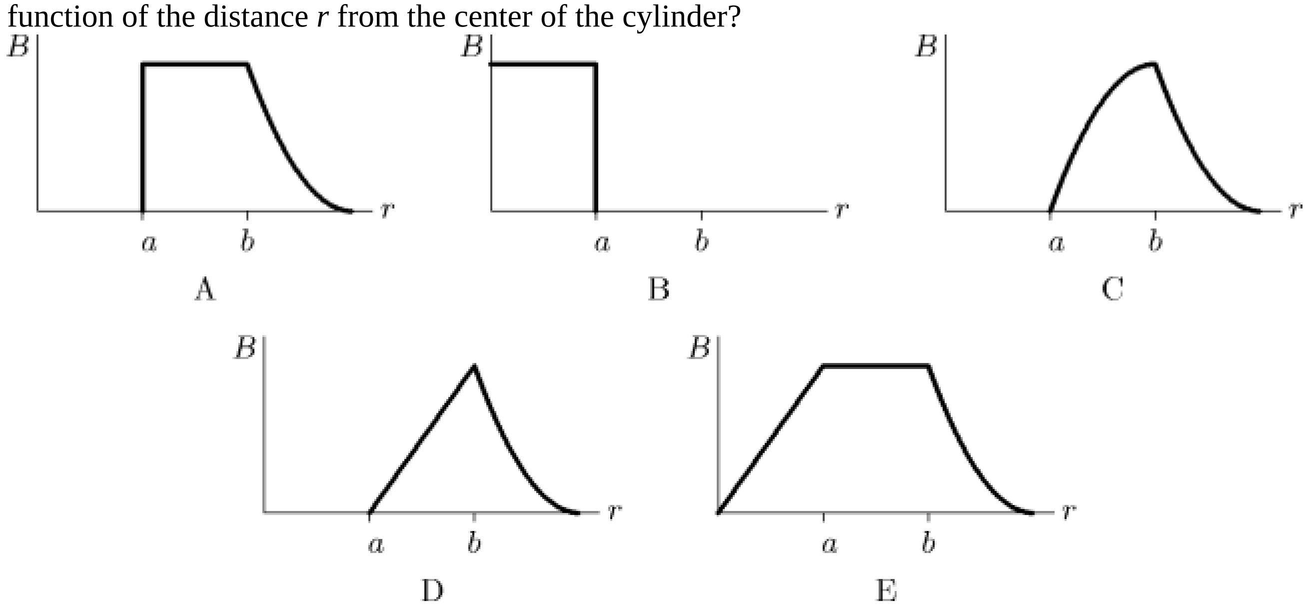
___ **14.** The magnetic field at any point is given by $\vec{B} = A\vec{r}\times\hat{k}$, where $\vec{r}$ is the position vector of the point and A is a constant. The net current through a circle of radius R, in the xy plane and centered at the origin is given by:
A) $\pi AR^2/\mu_0$ **B)** $2\pi AR/\mu_0$ **C)** $4\pi AR^3/3\mu_0$ **D)** $2\pi AR^2/\mu_0$ **E)** $\pi AR^2/2\mu_0$

___ **15.** The magnetic field $\vec{B}$ inside a long ideal solenoid is independent of:
A) the current
B) the core material
C) the spacing of the windings
D) the cross-sectional area of the solenoid
E) the direction of the current

___ **16.** A long straight cylindrical shell has inner radius R_i and outer radius R_o. It carries a current i, uniformly distributed over its cross section. A wire is parallel to the cylinder axis, in the hollow region ($r < R_i$). The magnetic field is zero everywhere in the hollow region. We conclude that the wire:

A) is on the cylinder axis and carries current i in the same direction as the current in the shell
B) may be anywhere in the hollow region but must be carrying current i in the direction opposite to that of the current in the shell
C) may be anywhere in the hollow region but must be carrying current i in the same direction as the current in the shell
D) is on the cylinder axis and carries current i in the direction opposite to that of the current in the shell
E) does not carry any current

___ **17.** A hollow cylindrical conductor (inner radius = a, outer radius = b) carries a current i uniformly spread over its cross section. Which graph below correctly gives B as a function of the distance r from the center of the cylinder?

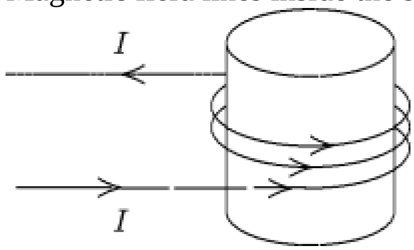


A) A **B)** B **C)** C **D)** D **E)** E

___ **18.** Two parallel wires carrying equal currents of 10 A attract each other with a force of 1 mN. If both currents are doubled, the force of attraction will be:

A) 1 mN **B)** 4 mN **C)** 0.5 mN **D)** 0.25 mN **E)** 2 mN

___ **19.** Magnetic field lines inside the solenoid shown are:



A) clockwise circles as one looks down the axis from the top of the page
B) counterclockwise circles as one looks down the axis from the top of the page
C) toward the top of the page
D) toward the bottom of the page
E) in no direction since $B = 0$

___ **20.** The magnetic field a distance 2 cm from a long straight current-carrying wire is 2.0×10^{-5} T. The current in the wire is:
A) 0.16 A **B)** 1.0 A **C)** 2.0 A **D)** 4.0 A **E)** 25 A

Answer Key

1. B
   Origin: Chapter 30- Magnetic Fields Due to Currents, 9
2. E
   Origin: Chapter 30- Magnetic Fields Due to Currents, 1
3. A
   Origin: Chapter 30- Magnetic Fields Due to Currents, 32
4. E
   Origin: Chapter 30- Magnetic Fields Due to Currents, 15
5. D
   Origin: Chapter 30- Magnetic Fields Due to Currents, 2
6. A
   Origin: Chapter 30- Magnetic Fields Due to Currents, 24
7. D
   Origin: Chapter 30- Magnetic Fields Due to Currents, 37
8. D
   Origin: Chapter 30- Magnetic Fields Due to Currents, 31
9. A
   Origin: Chapter 30- Magnetic Fields Due to Currents, 3
10. E
    Origin: Chapter 30- Magnetic Fields Due to Currents, 7
11. E
    Origin: Chapter 30- Magnetic Fields Due to Currents, 29
12. A
    Origin: Chapter 30- Magnetic Fields Due to Currents, 33
13. E
    Origin: Chapter 30- Magnetic Fields Due to Currents, 30
14. D
    Origin: Chapter 30- Magnetic Fields Due to Currents, 34
15. D
    Origin: Chapter 30- Magnetic Fields Due to Currents, 39
16. E
    Origin: Chapter 30- Magnetic Fields Due to Currents, 38
17. C
    Origin: Chapter 30- Magnetic Fields Due to Currents, 35
18. B
    Origin: Chapter 30- Magnetic Fields Due to Currents, 19
19. C
    Origin: Chapter 30- Magnetic Fields Due to Currents, 41
20. C
    Origin: Chapter 30- Magnetic Fields Due to Currents, 12

Name: ___________________________ Date: _____________

___ **1.** Suppose you are looking into one end of a long cylindrical tube in which there is a uniform electric field, pointing away from you. If the magnitude of the field is decreasing with time the field lines of the induced magnetic field are:
A) circles
B) ellipses
C) straight lines parallel to the electric field
D) straight lines perpendicular to the electric field
E) none of the above

___ **2.** A 10-turn conducting loop with a radius of 3.0 cm spins at 60 revolutions per second in a magnetic field of 0.50 T. The maximum emf generated is:
A) 0.014 V **B)** 0.53 V **C)** 5.3 V **D)** 18 V **E)** 180 V

___ **3.** A rectangular loop of wire has area A. It is placed perpendicular to a uniform magnetic field *B* and then spun around one of its sides at frequency *f*. The maximum induced emf is:
A) BAf **B)** BAf **C)** $2BAf$ **D)** $2\pi BAf$ **E)** $4\pi BAf$

___ **4.** A current of 1 A is used to charge a parallel plate capacitor with square plates. If the area of each plate is 0.6 m^2 the displacement current through a 0.3 m^2 area wholly between the capacitor plates and parallel to them is:
A) 1 A **B)** 2 A **C)** 0.7 A **D)** 0.5 A **E)** 0.25 A

___ **5.** One of the crucial facts upon which the Maxwell equations are based is:
A) the numerical value of the electron charge
B) charge is quantized
C) the numerical value of the charge/mass ratio of the electron
D) there are three types of magnetic materials
E) none of the above

___ **6.** Which of the following equations, along with a symmetry argument, can be used to calculate the magnetic field between the plates of a charging parallel plate capacitor with circular plates?
A) $\oint \vec{E}\cdot d\vec{A} = q/\varepsilon_0$
B) $\oint \vec{B}\cdot d\vec{A} = 0$
C) $\oint \vec{E}\cdot d\vec{s} = -d\Phi^{\text{mag}}/dt$
D) $\oint \vec{B}\cdot d\vec{s} = \mu_0 i + \mu_0\varepsilon_0 d\Phi^{\text{elec}}/dt$
E) None of these

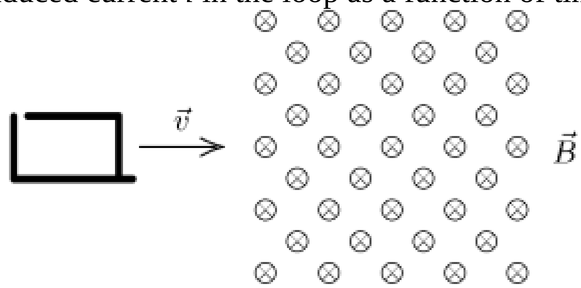
___ **7.** A single loop of wire with a radius of 7.5 cm rotates about a diameter in a uniform magnetic field of 1.6 T. To produce a maximum emf of 1.0 V, it should rotate at:
A) 0 **B)** 2.7 rad/s **C)** 5.6 rad/s **D)** 35 rad/s **E)** 71 rad/s

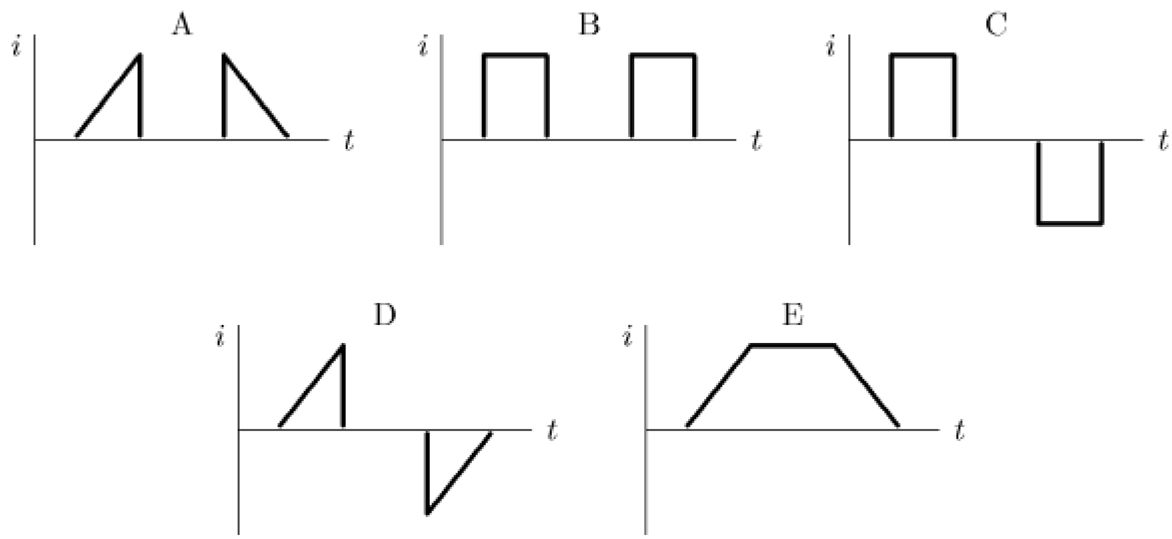
___ **8.** A 2-T uniform magnetic field makes an angle of 30º with the *z* axis. The magnetic flux through a 3-m^2 portion of the *xy* plane is:
A) 2.0 Wb **B)** 3.0 Wb **C)** 5.2 Wb **D)** 6.0 Wb **E)** 12 Wb

___ **9.** A magnetic field exists between the plates of a capacitor:
A) always
B) never
C) when the capacitor is fully charged
D) while the capacitor is being charged
E) only when the capacitor is starting to be charged

___ **10.** A vertical bar magnet is dropped through the center of a horizontal loop of wire, with its north pole leading. At the instant when the midpoint of the magnet is in the plane of the loop, the induced current at point P, viewed from above, is:
A) maximum and clockwise
B) maximum and counterclockwise
C) not maximum but clockwise
D) not maximum but counterclockwise
E) essentially zero

___ **11.** A square loop of wire moves with a constant speed *v* from a field-free region into a region of constant uniform magnetic field, as shown. Which of the five graphs correctly shows the induced current *i* in the loop as a function of time *t*?

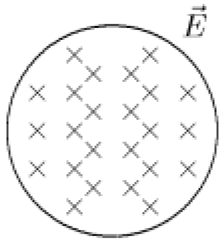


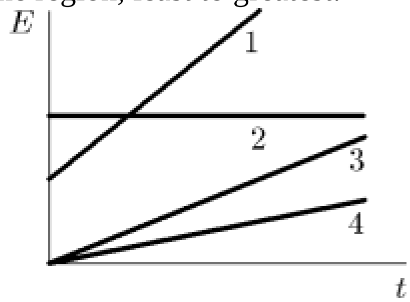


A) A **B)** B **C)** C **D)** D **E)** E

___ **12.** A cylindrical region of radius R = 3.0 cm contains a uniform magnetic field parallel to its axis. If the electric field induced at a point *R*/2 from the cylinder axis is 4.5×10^{-3} V/m the magnitude of the magnetic field must be changing at the rate:
A) 0 **B)** 0.30 T/s **C)** 0.60 T/s **D)** 1.2 T/s **E)** 2.4 T/s

___ **13.** An electric field exists in the cylindrical region shown and is parallel to the cylinder axis. The magnitude of the field might vary with time according to any of the four graphs shown. Rank the four variations according to the magnitudes of the magnetic field induced at the edge of the region, least to greatest.





A) 2, 4, 3, 1
B) 3 and 4 tie, then 1, 2
C) 4, 3, 2, 1
D) 4, 3, 1, 2
E) 2, 1, 3, 4

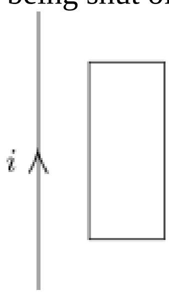
___ **14.** Two of Maxwell's equations contain a path integral on the left side and an area integral on the right. Suppose the area is the surface of a piece of paper at which you are looking and $d\vec{A}$ is chosen to point toward you. Then the path integral is:
A) clockwise around the circumference of the paper
B) counterclockwise around the circumference of the paper
C) from left to right
D) from right to left
E) from top to bottom

___ **15.** 1 weber is the same as:
A) 1 V · s **B)** 1 T · s **C)** 1 T/m **D)** 1 V/s **E)** 1 T/m^2

___ **16.** Maxwell's equations, along with an appropriate symmetry argument, can be used to calculate:
A) the electric force on a given charge
B) the magnetic force on a given moving charge
C) the flux of a given electric field
D) the flux of a given magnetic field
E) none of these

___ **17.** As a loop of wire with a resistance of 10 Ω moves in a non-uniform magnetic field, it loses kinetic energy at a uniform rate of 5 mJ/s. The induced emf in the loop:
A) is 0
B) is 0.2 V
C) is 0.28 V
D) is 2 V
E) cannot be calculated from the given data

___ **18.** A long straight wire is in the plane of a rectangular conducting loop. The straight wire initially carries a constant current *i* in the direction shown. While the current *i* is being shut off, the current in the rectangle is:



A) zero
B) clockwise
C) counterclockwise
D) clockwise in the left side and counterclockwise in the right side
E) counterclockwise in the left side and clockwise in the right side

___ **19.** Faraday's law states that an induced emf is proportional to:
A) the rate of change of the magnetic field
B) the rate of change of the electric field
C) the rate of change of the magnetic flux
D) the rate of change of the electric flux
E) zero

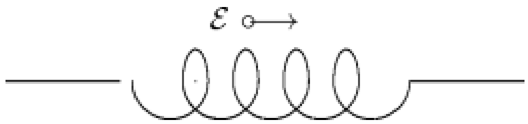
___ **20.** A 1.2-m radius cylindrical region contains a uniform electric field along the cylinder axis. It is increasing uniformly with time. To obtain a total displacement current of 2.0×10^{-9} A through a cross section of the region, the magnitude of the electric field should change at a rate of:
A) 5.0 V/m · s
B) 12 V/m · s
C) 37 V/m · s
D) 50 V/m · s
E) 4.0×10^{7} V/m · s

Answer Key

1. A
Origin: Chapter 31- Induction and Maxwell's Equations, 64
2. C
Origin: Chapter 31- Induction and Maxwell's Equations, 40
3. D
Origin: Chapter 31- Induction and Maxwell's Equations, 36
4. D
Origin: Chapter 31- Induction and Maxwell's Equations, 60
5. E
Origin: Chapter 31- Induction and Maxwell's Equations, 83
6. D
Origin: Chapter 31- Induction and Maxwell's Equations, 93
7. D
Origin: Chapter 31- Induction and Maxwell's Equations, 41
8. C
Origin: Chapter 31- Induction and Maxwell's Equations, 3
9. D
Origin: Chapter 31- Induction and Maxwell's Equations, 62
10. E
Origin: Chapter 31- Induction and Maxwell's Equations, 19
11. C
Origin: Chapter 31- Induction and Maxwell's Equations, 31
12. C
Origin: Chapter 31- Induction and Maxwell's Equations, 49
13. A
Origin: Chapter 31- Induction and Maxwell's Equations, 57
14. B
Origin: Chapter 31- Induction and Maxwell's Equations, 87
15. A
Origin: Chapter 31- Induction and Maxwell's Equations, 6
16. E
Origin: Chapter 31- Induction and Maxwell's Equations, 94
17. B
Origin: Chapter 31- Induction and Maxwell's Equations, 47
18. B
Origin: Chapter 31- Induction and Maxwell's Equations, 16
19. C
Origin: Chapter 31- Induction and Maxwell's Equations, 8
20. D
Origin: Chapter 31- Induction and Maxwell's Equations, 59

Name: ___________________________ Date: _____________

___ **1.** The diagram shows an inductor that is part of a circuit. The direction of the emf induced in the inductor is indicated. Which of the following is possible?



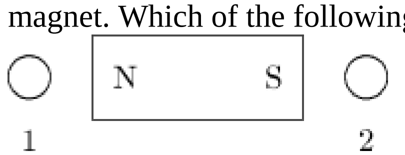
A) The current is constant and rightward
B) The current is constant and leftward
C) The current is increasing and rightward
D) The current is increasing and leftward
E) None of the above

___ **2.** An electron traveling with speed v around a circle of radius r is equivalent to a current of:
A) $evr/2$ **B)** ev/r **C)** $ev/2\pi r$ **D)** $2\pi er/v$ **E)** $2\pi ev/r$

___ **3.** An inductor with inductance L and an inductor with inductance $2L$ are connected in parallel. When the rate of change of the current in the larger inductor is 1200 A/s the rate of change of the current in the smaller inductor is:
A) 400 A/s **B)** 1200 A/s **C)** 1600 A/s **D)** 2000 A/s **E)** 2400 A/s

___ **4.** A 3.5-mH inductor and a 4.5-mH inductor are connected in series. The equivalent inductance is:
A) 2.0 mH **B)** 0.51 mH **C)** 0.13 mH **D)** 1.0 mH **E)** 8.0 mH

___ **5.** The diagram shows two small paramagnetic spheres, one near each end of a bar magnet. Which of the following statements is true?



A) The force on 1 is toward the magnet and the force on 2 is away from the magnet
B) The force on 1 is away from the magnet and the force on 2 is away from the magnet
C) The forces on 1 and 2 are both toward the magnet
D) The forces on 1 and 2 are both away from the magnet
E) The magnet does not exert a force on either sphere

___ **6.** A magnetic field $\vec{B}^{\text{ext}}$ is applied to a diamagnetic substance. In the interior the magnetic field produced by the magnetic dipoles of the substance is:

A) greater in magnitude than $\vec{B}^{\text{ext}}$ and in the opposite direction
B) less in magnitude than $\vec{B}^{\text{ext}}$ and in the opposite direction
C) greater in magnitude than $\vec{B}^{\text{ext}}$ and in the same direction
D) less in magnitude than $\vec{B}^{\text{ext}}$ and in the same direction
E) the same as $\vec{B}^{\text{ext}}$

___ **7.** Paramagnetism is closely associated with:

A) the tendency of electron dipole moments to align with an applied magnetic field
B) the tendency of electron dipole moments to align opposite to an applied magnetic field
C) the exchange force between electrons
D) the force exerted by electron dipole moments on each other
E) the torque exerted by electron dipole moments on each other

___ **8.** A 10-turn ideal solenoid has an inductance of 4.0 mH. To generate an emf of 2.0 V the current should change at a rate of:

A) zero **B)** 5.0 A/s **C)** 50 A/s **D)** 250 A/s **E)** 500 A/s

___ **9.** The core of a transformer is made in a laminated form to:

A) facilitate easy assembly
B) reduce i^2R losses in the coils
C) increase the magnetic flux
D) save weight
E) prevent eddy currents

___ **10.** A paramagnetic substance, in an external magnetic field, is thermally isolated. The field is then removed. As a result:

A) the magnetic energy of the magnetic dipoles decreases
B) the temperature of the substance increases
C) the magnetization decreases, but only slightly
D) the magnetization reverses direction
E) none of the above

___ **11.** An inductance L, resistance R, and ideal battery of emf ε are wired in series. A switch in the circuit is closed at time 0, at which time the current is zero. At any later time t the emf of the inductor is given by:

A) $\varepsilon(1 - e^{-Lt/R})$ **B)** $\varepsilon e^{-Lt/R}$ **C)** $\varepsilon(1 + e^{-Rt/L})$ **D)** $\varepsilon e^{-Rt/L}$ **E)** $\varepsilon(1 - e^{-Rt/L})$

___ **12.** A paramagnetic substance is placed in a weak magnetic field and its absolute temperature T is increased. As a result, its magnetization:
A) increases in proportion to T
B) increases in proportion to T^2
C) remains the same
D) decreases in proportion to $1/T$
E) decreases in proportion to $1/T^2$

___ **13.** A 3.5-mH inductor and a 4.5-mH inductor are connected in series and a time varying current is established in them. When the total emf of the combination is 16 V, the emf of the larger inductor is:
A) 7.0 V **B)** 9.0 V **C)** 2.3 V **D)** 28 V **E)** 36 V

___ **14.** The primary of a 3:1 step-up transformer is connected to a source and the secondary is connected to a resistor R. The power dissipated by R in this situation is P. If R is connected directly to the source it will dissipate a power of:
A) $P/9$ **B)** $P/3$ **C)** P **D)** $3P$ **E)** $9P$

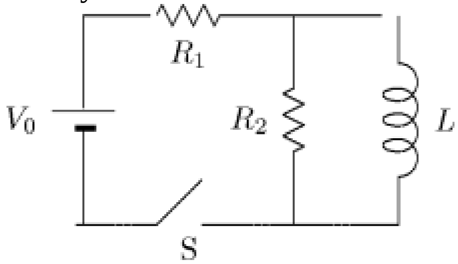
___ **15.** A positively charged ion, due to a cosmic ray, is headed through Earth's atmosphere toward the center of Earth. Due to Earth's magnetic field, the ion will be deflected:
A) south
B) north
C) west
D) east
E) not at all since it is a charge and not a pole

___ **16.** Because ferromagnets have ferromagnetic domains, the net magnetization:
A) can never be in the same direction as an applied field
B) may not vanish when an applied field is reduced to zero
C) can never vanish
D) is proportional to any applied magnetic field
E) is always opposite to the direction of any applied magnetic field

___ **17.** Of the three chief kinds of magnetic materials (diamagnetic, paramagnetic, and ferromagnetic), which are used to make permanent magnets?
A) Only diamagnetic
B) Only ferromagnetic
C) Only paramagnetic
D) Only paramagnetic and ferromagnetic
E) All three

___ **18.** A generator supplies 100 V to the primary coil of a transformer. The primary has 50 turns and the secondary has 500 turns. The secondary voltage is:
A) 1000 V **B)** 500 V **C)** 250 V **D)** 100 V **E)** 10 V

___ **19.** Immediately after switch S in the circuit shown is closed, the current through the battery is:



A) 0 **B)** V_0/R_1 **C)** V_0/R_2 **D)** $V_0/(R_1 + R_2)$ **E)** $V_0(R_1 + R_2)/(R_1R_2)$

___ **20.** Lenz' law can explain:

A) paramagnetism only
B) diamagnetism only
C) ferromagnetism only
D) only two of the three types of magnetism
E) all three of the types of magnetism

Answer Key

1. D
Origin: Chapter 32- Inductors and Magnetic Materials, 2
2. C
Origin: Chapter 32- Inductors and Magnetic Materials, 39
3. E
Origin: Chapter 32- Inductors and Magnetic Materials, 22
4. E
Origin: Chapter 32- Inductors and Magnetic Materials, 18
5. C
Origin: Chapter 32- Inductors and Magnetic Materials, 57
6. B
Origin: Chapter 32- Inductors and Magnetic Materials, 61
7. A
Origin: Chapter 32- Inductors and Magnetic Materials, 56
8. E
Origin: Chapter 32- Inductors and Magnetic Materials, 4
9. E
Origin: Chapter 32- Inductors and Magnetic Materials, 25
10. E
Origin: Chapter 32- Inductors and Magnetic Materials, 60
11. D
Origin: Chapter 32- Inductors and Magnetic Materials, 8
12. D
Origin: Chapter 32- Inductors and Magnetic Materials, 58
13. B
Origin: Chapter 32- Inductors and Magnetic Materials, 19
14. A
Origin: Chapter 32- Inductors and Magnetic Materials, 29
15. D
Origin: Chapter 32- Inductors and Magnetic Materials, 64
16. B
Origin: Chapter 32- Inductors and Magnetic Materials, 51
17. B
Origin: Chapter 32- Inductors and Magnetic Materials, 47
18. A
Origin: Chapter 32- Inductors and Magnetic Materials, 26
19. D
Origin: Chapter 32- Inductors and Magnetic Materials, 17
20. B
Origin: Chapter 32- Inductors and Magnetic Materials, 54

Name: ___________________________ Date: _____________

___ **1.** A series *RL* circuit is connected to an emf source of angular frequency ω. The current:

A) leads the applied emf by $\tan^{-1}(\omega L/R)$
B) lags the applied emf by $\tan^{-1}(\omega L/R)$
C) lags the applied emf by $\tan^{-1}(\omega R/L)$
D) leads the applied emf by $\tan^{-1}(\omega R/L)$
E) is zero

___ **2.** A current of 10 A in a certain inductor results in a stored energy of 40 J. When the current is changed to 5 A in the opposite direction, the stored energy changes by:

A) 20 J **B)** 30 J **C)** 40 J **D)** 50 J **E)** 60 J

___ **3.** In a purely inductive circuit, the current lags the voltage by:

A) zero
B) one-fourth of a cycle
C) one-half of a cycle
D) three-fourths of a cycle
E) one cycle

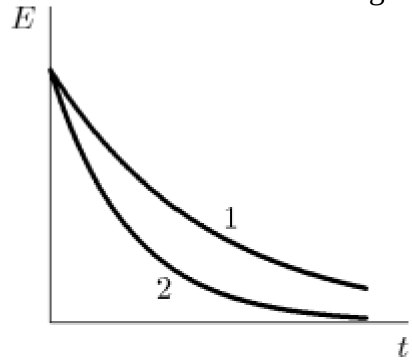
___ **4.** An *LC* circuit has a capacitance of 30 μF and an inductance of 15 mH. At time $t = 0$ the charge on the capacitor is 10 μC and the current is 20 mA. The maximum charge on the capacitor is:

A) 8.9 μC **B)** 10 μC **C)** 12 μC **D)** 17 μC **E)** 24 μC

___ **5.** A resistor, an inductor, and a capacitor are connected in parallel to a sinusoidal source of emf. Which of the following is true?

A) The currents in all branches are in phase.
B) The potential differences across all branches are in phase.
C) The current in the capacitor branch leads the current in the inductor branch by one-fourth of a cycle
D) The potential difference across the capacitor branch leads the potential difference across the inductor branch by one-fourth of a cycle.
E) The current in the capacitor branch lags the current in the inductor branch by one-fourth of a cycle.

___ **6.** The graphs show the total electromagnetic energy in two RLC circuits as functions of time. Which of the following statements might be true?



A) Circuit 1 has a smaller resistance and a larger inductance
B) Circuit 1 has a larger resistance and a smaller inductance
C) Circuit 1 has the same resistance and a larger inductance
D) Circuit 1 has a larger resistance and a larger capacitance
E) Circuit 1 has the same resistance and a smaller capacitance

___ **7.** An *LC* circuit has an inductance of 20 mH and a capacitance of 5.0 μF. At time $t = 0$ the charge on the capacitor is 3.0 μC and the current is 7.0 mA. The total energy is:
A) 4.1×10^{-7} J
B) 4.9×10^{-7} J
C) 9.0×10^{-7} J
D) 1.4×10^{-6} J
E) 2.8×10^{-6} J

___ **8.** An *LC* circuit has an oscillation frequency of 10^5 Hz. If the capacitance is 0.1 μF, then the inductance must be about:
A) 10 mH **B)** 1 mH **C)** 25 μH **D)** 2.5 μH **E)** 1 pH

___ **9.** When the amplitude of the oscillator in a series *RLC* circuit is doubled:
A) the impedance is doubled
B) the voltage across the capacitor is halved
C) the capacitive reactance is halved
D) the power factor is doubled
E) the current amplitude is doubled

___ **10.** A charged capacitor and an inductor are connected in series. At time $t = 0$ the current is zero, but the capacitor is charged. If T is the period of the resulting oscillations, the next time after $t = 0$ that the energy stored in the magnetic field of the inductor is a maximum is:
A) T **B)** $T/4$ **C)** $T/2$ **D)** T **E)** $2T$

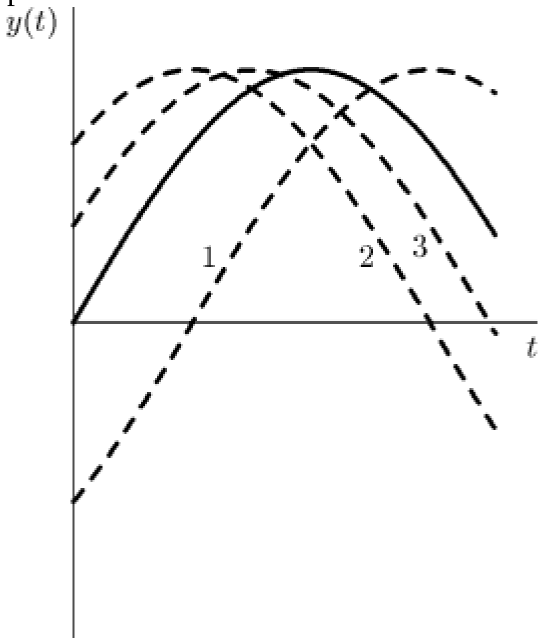
___ **11.** A charged capacitor and an inductor are connected in series. At time $t = 0$ the current is zero, but the capacitor is charged. If T is the period of the resulting oscillations, the next time after $t = 0$ that the energy stored in the electric field of the capacitor is a maximum is:
A) T **B)** $T/4$ **C)** $T/2$ **D)** T **E)** $2T$

___ **12.** An *RLC* series circuit has $L = 100$ mH and $C = 1\ \mu$F. It is connected to a 1000-Hz source and the source emf is found to lead the current by 75°. The value of R is:
A) 12.6 Ω **B)** 126 Ω **C)** 175 Ω **D)** 1750 Ω **E)** 1810 Ω

___ **13.** An inductance L and a resistance R are connected in series to an ideal battery. A switch in the circuit is closed at time 0, at which time the current is zero. The energy stored in the inductor is a maximum:
A) just after the switch is closed
B) at the time $t = L/R$ after the switch is closed
C) at the time $t = L/R$ after the switch is closed
D) at the time $t = 2L/R$ after the switch is closed
E) a long time after the switch is closed

___ **14.** An *RLC* circuit has an inductance of 25 mH and a capacitance of 5.0 μF. The charge on the capacitor does NOT oscillate but rather decays exponentially to zero. The resistance in the circuit must be:
A) greater than or equal to 20,000Ω
B) less than 20,000Ω but greater than 10,000Ω
C) less than 10,000Ω but greater than 5,000Ω
D) less than 5,000Ω but greater than 0
E) 0

___ **15.** In the diagram, the function $y(t) = y_m \sin(\omega t)$ is plotted as a solid curve. The other three curves have the form $y(t) = y_m \sin(\omega t + \phi)$, where ϕ is between $-\pi/2$ and $+\pi/2$. Rank the curves according to the value of ϕ, from the most negative to the most positive.

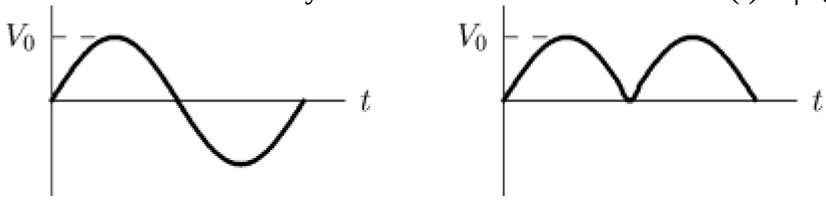


A) 1, 2, 3 **B)** 2, 3, 1 **C)** 3, 2, 1 **D)** 1, 3, 2 **E)** 2, 1, 3

___ **16.** An ac generator producing 10 V (rms) at 200 rad/s is connected in series with a 50-Ω resistor, a 400-mH inductor, and a 200-μF capacitor. The rms voltage (in volts) across the inductor is:
A) 2.5 **B)** 3.4 **C)** 6.7 **D)** 10.0 **E)** 10.8

___ **17.** The rapid exponential decay in just a few cycles of the charge on the plates of capacitor in an *RLC* circuit might be due to:
A) a large inductance
B) a large capacitance
C) a small capacitance
D) a large resistance
E) a small resistance

___ **18.** The rms value of a sinusoidal voltage is $V_0/\sqrt{2}$, where V_0 is the amplitude. What is the rms value of its fully rectified wave? Recall that $V_{rect}(t) = |V(t)|$.



A) $V_0^2/\sqrt{2}$ **B)** $V_0^2/2$ **C)** $\sqrt{2}V_0$ **D)** $V_0/\sqrt{2}$ **E)** $V_0/(2\sqrt{2})$

___ **19.** An *RLC* circuit has a resistance of 200 Ω and an inductance of 15 mH. Its oscillation frequency is 7000 Hz. At time $t = 0$ the current is 25 mA and there is no charge on the capacitor. After five complete cycles the current is:

A) zero
B) 1.8×10^{-6} A
C) 2.1×10^{-4} A
D) 2.3×10^{-3} A
E) 2.5×10^{-2} A

___ **20.** In a sinusoidally driven series *RLC* circuit the current lags the applied emf. The rate at which energy is dissipated in the resistor can be increased by:

A) decreasing the capacitance and making no other changes
B) increasing the capacitance and making no other changes
C) increasing the inductance and making no other changes
D) increasing the driving frequency and making no other changes
E) decreasing the amplitude of the driving emf and making no other changes

Answer Key

1. B
   Origin: Chapter 33- Electromagnetic Oscillations and Alternating Current, 49
2. B
   Origin: Chapter 33- Electromagnetic Oscillations and Alternating Current, 5
3. B
   Origin: Chapter 33- Electromagnetic Oscillations and Alternating Current, 48
4. D
   Origin: Chapter 33- Electromagnetic Oscillations and Alternating Current, 34
5. B
   Origin: Chapter 33- Electromagnetic Oscillations and Alternating Current, 71
6. A
   Origin: Chapter 33- Electromagnetic Oscillations and Alternating Current, 37
7. D
   Origin: Chapter 33- Electromagnetic Oscillations and Alternating Current, 33
8. C
   Origin: Chapter 33- Electromagnetic Oscillations and Alternating Current, 18
9. E
   Origin: Chapter 33- Electromagnetic Oscillations and Alternating Current, 61
10. B
    Origin: Chapter 33- Electromagnetic Oscillations and Alternating Current, 12
11. C
    Origin: Chapter 33- Electromagnetic Oscillations and Alternating Current, 13
12. B
    Origin: Chapter 33- Electromagnetic Oscillations and Alternating Current, 65
13. E
    Origin: Chapter 33- Electromagnetic Oscillations and Alternating Current, 2
14. A
    Origin: Chapter 33- Electromagnetic Oscillations and Alternating Current, 39
15. D
    Origin: Chapter 33- Electromagnetic Oscillations and Alternating Current, 64
16. E
    Origin: Chapter 33- Electromagnetic Oscillations and Alternating Current, 78
17. D
    Origin: Chapter 33- Electromagnetic Oscillations and Alternating Current, 41
18. D
    Origin: Chapter 33- Electromagnetic Oscillations and Alternating Current, 73
19. C
    Origin: Chapter 33- Electromagnetic Oscillations and Alternating Current, 38
20. A
    Origin: Chapter 33- Electromagnetic Oscillations and Alternating Current, 68

Name: ____________________________ Date: ______________

___ **1.** If the magnetic field in a plane electromagnetic wave is along the y axis and its component is given by $B^{max} \sin(kx - \omega t)$, in SI units, then the electric field is along the z axis and its component is given by:

A) $(cB^{max}) \cos(kx - \omega t)$
B) $-(cB^{max}/c) \cos(kx - \omega t)$
C) $-(cB^{max}/c) \sin(kx - \omega t)$
D) $B^{max} \cos(kx - \omega t)$
E) $(cB^{max}/c) \sin(kx - \omega t)$

___ **2.** Which of the following types of electromagnetic radiation travels at the greatest speed in vacuum?

A) Radio waves
B) Visible light
C) X rays
D) Gamma rays
E) All of these travel at the same speed

___ **3.** The Sun is about 1.5×10^{11} m away. The time for light to travel this distance is about:

A) 4.5×10^{18} s **B)** 8 s **C)** 8 min **D)** 8 hr **E)** 8 yr

___ **4.** The order of increasing wavelength for blue (b), green (g), red (r), and yellow (y) light is:

A) r, y, g, b **B)** r, g, y, b **C)** g, y, b, r **D)** b, g, y, r **E)** b, y, g, r

___ **5.** If the electric field in a plane electromagnetic wave is along the y axis and its component is given by $E^{max} \sin(kx + \omega t)$, in SI units, then the magnetic field is along the z axis and its component is given by:

A) $(E^{max}/c) \cos(kx + \omega t)$
B) $-(E^{max}/c) \cos(kx + \omega t)$
C) $-(E^{max}/c) \sin(kx + \omega t)$
D) $E^{max} \cos(kx + \omega t)$
E) $(E^{max}/c) \sin(kx + \omega t)$

___ **6.** A sinusoidal electromagnetic wave with a maximum electric field of 100 V/m is incident normally on a surface with an area of 1 cm^2 and is completely absorbed. The energy absorbed in 10 s is:

A) 1.3 mJ **B)** 13 mJ **C)** 27 mJ **D)** 130 mJ **E)** 270 mJ

___ **7.** The electric field in unpolarized light:
A) has no direction at any time
B) rotates rapidly
C) is always parallel to the direction of propagation
D) changes direction randomly and often
E) remains along the same line but reverses direction randomly and often

___ **8.** The theoretical upper limit for the frequency of electromagnetic waves is:
A) just slightly greater than that of red light
B) just slightly less than that of blue light
C) the greatest x-ray frequency
D) none of the above (there is no upper limit)
E) none of the above (but there is an upper limit)

___ **9.** The product $\mu_0\varepsilon_0$ has the same units as:
A) $(\text{velocity})^2$ **B)** $(\text{velocity})^{1/2}$ **C)** 1/velocity **D)** $1/\text{velocity}^2$ **E)** $1/\text{velocity}^{1/2}$

___ **10.** The light intensity 10 m from a point source is 1000 W/m^2. The intensity 100 m from the same source is:
A) 1000 W/m^2 **B)** 100 W/m^2 **C)** 10 W/m^2 **D)** 1 W/m^2 **E)** 0.1 W/m^2

___ **11.** Radio waves of wavelength 300 m have a frequency of:
A) 10^{-3} kHz **B)** 500 kHz **C)** 1 MHz **D)** 9 MHz **E)** 108 kHz

___ **12.** Select the correct statement:
A) ultraviolet light has a longer wavelength than infrared
B) blue light has a higher frequency than *x* rays
C) radio waves have higher frequency than gamma rays
D) gamma rays have higher frequency than infrared waves
E) electrons are a type of electromagnetic wave

___ **13.** In a stack of three polarizing sheets the first and third are crossed while the middle one has its axis at 45º to the axes of the other two. The fraction of the intensity of an incident unpolarized beam of light that is transmitted by the stack is:
A) 1/2 **B)** 1/3 **C)** 1/4 **D)** 1/8 **E)** 0

___ **14.** An unpolarized beam of light has intensity I_0. It is incident on two ideal polarizing sheets. The angle between the axes of polarization of these sheets is θ. Find θ if the emerging light has intensity $I_0/4$:

A) $\sin^{-1}(1/2)$
B) $\sin^{-1}(1/\sqrt{5})$
C) $\cos^{-1}(1/2)$
D) $\cos^{-1}(1/\sqrt{2})$
E) $\tan^{-1}(1/4)$

___ **15.** Polarization experiments provide evidence that light is:

A) a longitudinal wave
B) a stream of particles
C) a transverse wave
D) some type of wave
E) nearly monochromatic

___ **16.** In a plane electromagnetic wave in vacuum, the ratio $E^{\max}/B^{\max}$ of the field maxima in SI units is:

A) the speed of light
B) an increasing function of frequency
C) a decreasing function of frequency
D) $\sqrt{2}$
E) $1/\sqrt{2}$

___ **17.** The dimensions of $\vec{S} = (1/\mu_0)\vec{E} \times \vec{B}$ are:

A) J/m^2 **B)** J/s **C)** W/s **D)** W/m^2 **E)** J/m^3

___ **18.** Of the following human eyes are most sensitive to:

A) red light
B) violet light
C) blue light
D) green light
E) none of these (they are equally sensitive to all colors)

___ **19.** Radio waves differ from visible light waves in that radio waves:

A) travel slower
B) have a higher frequency
C) travel faster
D) have a lower frequency
E) require a material medium

___ **20.** Consider: radio waves (r), visible light (v), infrared light (i), x-rays (x), and ultraviolet light (u). In order of increasing frequency, they are:

A) r, v, i, x, u **B)** r, i, v, u, x **C)** i, r, v, u, x **D)** i, v, r, u, x **E)** r, i, v, x, u

Answer Key

1. E
   Origin: Chapter 34- Electromagnetic Waves, 19
2. E
   Origin: Chapter 34- Electromagnetic Waves, 8
3. C
   Origin: Chapter 34- Electromagnetic Waves, 6
4. D
   Origin: Chapter 34- Electromagnetic Waves, 53
5. C
   Origin: Chapter 34- Electromagnetic Waves, 20
6. B
   Origin: Chapter 34- Electromagnetic Waves, 32
7. D
   Origin: Chapter 34- Electromagnetic Waves, 44
8. D
   Origin: Chapter 34- Electromagnetic Waves, 11
9. D
   Origin: Chapter 34- Electromagnetic Waves, 2
10. C
    Origin: Chapter 34- Electromagnetic Waves, 29
11. C
    Origin: Chapter 34- Electromagnetic Waves, 13
12. D
    Origin: Chapter 34- Electromagnetic Waves, 51
13. D
    Origin: Chapter 34- Electromagnetic Waves, 48
14. D
    Origin: Chapter 34- Electromagnetic Waves, 47
15. C
    Origin: Chapter 34- Electromagnetic Waves, 40
16. A
    Origin: Chapter 34- Electromagnetic Waves, 18
17. D
    Origin: Chapter 34- Electromagnetic Waves, 24
18. D
    Origin: Chapter 34- Electromagnetic Waves, 54
19. D
    Origin: Chapter 34- Electromagnetic Waves, 9
20. B
    Origin: Chapter 34- Electromagnetic Waves, 52

Name: ___________________________ Date: _____________

___ **1.** As used in the laws of reflection and refraction, the “normal” direction is:
A) any convenient direction
B) tangent to the interface
C) along the incident ray
D) perpendicular to the electric field vector of the light
E) perpendicular to the interface

___ **2.** If $n_{\text{water}} = 1.50$ and $n_{\text{glass}} = 1.33$, then total internal reflection at an interface between this glass and water:
A) occurs whenever the light goes from glass to water
B) occurs whenever the light goes from water to glass
C) may occur when the light goes from glass to water
D) may occur when the light goes from water to glass
E) can never occur at this interface

___ **3.** Let f_o and f_e be the focal lengths of the objective and eyepiece of a compound microscope. In ordinary use, the object:
A) is less than f_o from the objective lens
B) is more that f_o from the objective
C) produces an intermediate image that is slightly more than f_e from the eyepiece
D) produces an intermediate image that is 2 f_e away from the eyepiece
E) produces an intermediate image that is less than f_o from the objective lens

___ **4.** Real images formed by a spherical mirror are always:
A) on the side of the mirror opposite the source
B) on the same side of the mirror as the source but closer to the mirror than the source
C) on the same side of the mirror as the source but closer to the mirror than the focal point
D) on the same side of the mirror as the source but further from the mirror than the focal point
E) none of the above

___ **5.** A ray of light passes obliquely through a plate of glass having parallel faces. The emerging ray:
A) is totally internally reflected
B) is bent more toward the normal than the incident ray
C) is bent further away from the normal than the incident ray
D) is parallel to the incident ray but displaced sideways
E) lies on the same straight line as the incident ray

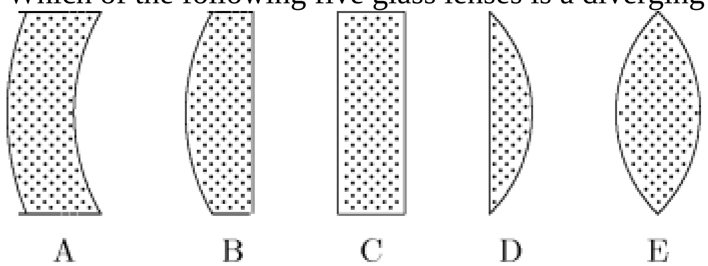
___ **6.** A student sets the cross-hairs of an eyepiece in line with an image that he is measuring. He then notes that when he moves his head slightly to the right, the image moves slightly to the left (with respect to the cross-hairs). Therefore the image is:
A) infinitely far away
B) farther away from him that the cross-hairs
C) nearer to him than the cross-hairs
D) in the focal plane of the eyepiece
E) in the plane of the cross-hairs

___ **7.** A man stands with his nose 8 cm from a concave shaving mirror of radius 32 cm The distance from the mirror to the image of his nose is:
A) 8 cm **B)** 12 cm **C)** 16 cm **D)** 24 cm **E)** 32 cm

___ **8.** Consider the following four statements concerning a compound microscope:
1. Each lens produces an image that is virtual and inverted.
2. The objective lens has a very short focal length.
3. The eyepiece is used as a simple magnifying glass.
4. The objective lens is convex and the eyepiece is concave.
Which two of the four statements are correct?
A) 1, 2 **B)** 1, 3 **C)** 1, 4 **D)** 2, 3 **E)** 2, 4

___ **9.** The index of refraction of a substance is:
A) the speed of light in the substance
B) the angle of refraction
C) the angle of incidence
D) the speed of light in vacuum divided by the speed of light in the substance
E) measured in radians

___ **10.** Which of the following five glass lenses is a diverging lens?



A) A **B)** B **C)** C **D)** D **E)** E

___ **11.** A magnifying glass has a focal length of 15 cm. If the near point of the eye is 25 cm from the eye the angular magnification of the glass is about:
A) 0.067 **B)** 0.33 **C)** 0.67 **D)** 1.7 **E)** 15

___ **12.** Where must an object be placed in front of a converging lens in order to obtain a virtual image?
A) At the focal point
B) At twice the focal length
C) Greater than the focal length
D) Between the focal point and the lens
E) Between the focal length and twice the focal length

___ **13.** A pole stands in a river, half in and half out of the water. Another pole of the same length stands vertically on the shore at a place where the ground is level. The shadow cast by the pole in the river on the river bottom is:
A) slightly longer than the shadow of the pole on land
B) much longer than the shadow of the pole on land
C) shorter than the shadow of the pole on land
D) shorter than the shadow of the pole on land if the Sun is high and longer if the sun is low
E) the same length as the shadow of the pole on land

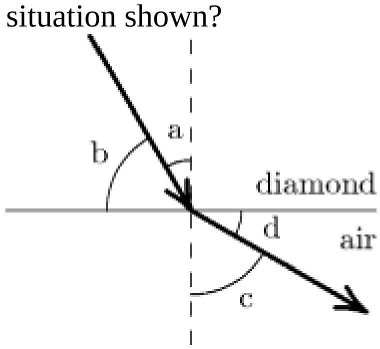
___ **14.** A convex spherical refracting surface separates a medium with index of refraction 2 from air. The image of an object outside the surface is real:
A) always
B) never
C) only if it is close to the surface
D) only if it is far from the surface
E) only if the radius of curvature is small

___ **15.** The relation $n_1 \sin \theta_1 = n_2 \sin \theta_2$, which applies as a ray of light strikes an interface between two media, is known as:
A) Gauss' law
B) Snell's law
C) Faraday's law
D) Cole's law
E) law of sines

___ **16.** When you stand in front of a plane mirror, your image is:
A) real, erect, and smaller than you
B) real, erect, and the same size as you
C) virtual, erect, and smaller than you
D) virtual, erect, and the same size as you
E) real, inverted, and the same size as you

___ **17.** In a two lens microscope, the intermediate image is:
A) virtual, erect, and magnified
B) real, erect, and magnified
C) real, inverted, and magnified
D) virtual, inverted, and reduced
E) virtual, inverted, and magnified

___ **18.** The index of refraction for diamond is 2.5. Which of the following is correct for the situation shown?



A) $(\sin a)/(\sin b) = 2.5$
B) $(\sin b)/(\sin d) = 2.5$
C) $(\cos a)/(\cos c) = 2.5$
D) $(\sin c)/(\sin a) = 2.5$
E) $a/c = 2.5$

___ **19.** A concave spherical surface with radius r separates a medium with index of refraction 2 from air. As an object is moved toward the surface from far away along the central axis, its image:
A) changes from virtual to real when it is $r/2$ from the surface
B) changes from virtual to real when it is $2r$ from the surface
C) changes from real to virtual when it is $r/2$ from the surface
D) changes from real to virtual when it is $2r$ from the surface
E) remains virtual

___ **20.** An object is in front of a converging lens, at a distance less than the focal length from the lens. Its image is:

A) virtual and larger than the object
B) real and smaller than the object
C) virtual and smaller than the object
D) real and larger than the object
E) virtual and the same size as the object

Answer Key

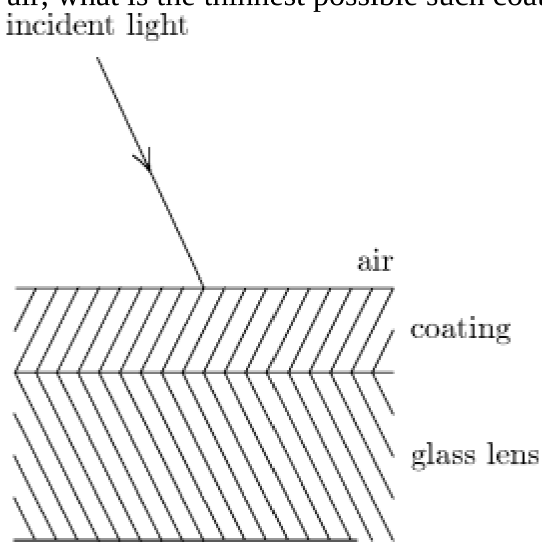
1. E
Origin: Chapter 35- Images, 3
2. D
Origin: Chapter 35- Images, 22
3. B
Origin: Chapter 35- Images, 86
4. E
Origin: Chapter 35- Images, 41
5. D
Origin: Chapter 35- Images, 12
6. C
Origin: Chapter 35- Images, 94
7. C
Origin: Chapter 35- Images, 51
8. D
Origin: Chapter 35- Images, 87
9. D
Origin: Chapter 35- Images, 5
10. A
Origin: Chapter 35- Images, 79
11. D
Origin: Chapter 35- Images, 91
12. D
Origin: Chapter 35- Images, 67
13. C
Origin: Chapter 35- Images, 16
14. D
Origin: Chapter 35- Images, 63
15. B
Origin: Chapter 35- Images, 2
16. D
Origin: Chapter 35- Images, 28
17. C
Origin: Chapter 35- Images, 95
18. D
Origin: Chapter 35- Images, 10
19. E
Origin: Chapter 35- Images, 65
20. A
Origin: Chapter 35- Images, 77

Name: ___________________________ Date: _____________

___ **1.** In an experiment to measure the wavelength of light using a double slit, it is found that the fringes are too close together to easily count them. To spread out the fringe pattern, one could:

A) decrease the slit separation
B) increase the slit separation
C) increase the width of each slit
D) decrease the width of each slit
E) none of these

___ **2.** A lens with a refractive index of 1.5 is coated with a material of refractive index 1.2 in order to minimize reflection. If λ denotes the wavelength of the incident light in air, what is the thinnest possible such coating?

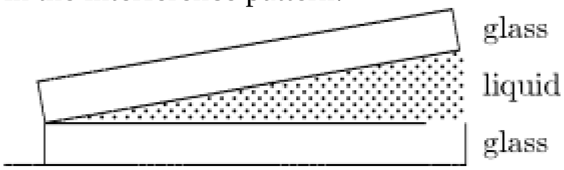


A) 0.5λ **B)** 0.416λ **C)** 0.3λ **D)** 0.208λ **E)** 0.25λ

___ **3.** A light wave with an electric field amplitude of $2E_0$ and a phase constant of zero is to be combined with one of the following waves: Which of these combinations produces the least intensity?

A) wave A has an amplitude of E_0 and a phase constant of zero
B) wave B has an amplitude of E_0 and a phase constant of π
C) wave C has an amplitude of $2E_0$ and a phase constant of zero
D) wave D has an amplitude of $2E_0$ and a phase constant of π
E) wave E has an amplitude of $3E_0$ and a phase constant of π

___ **4.** A liquid of refractive index n = 4/3 replaces the air between a fixed wedge formed from two glass plates as shown. As a result, the spacing between adjacent dark bands in the interference pattern:



A) increases by a factor of 4/3
B) increases by a factor of 3
C) remains the same
D) decreases to 3/4 of its original value
E) decreases to 1/3 of its original value

___ **5.** Monochromatic light, at normal incidence, strikes a thin film in air. If λ denotes the wavelength in the film, what is the thinnest film in which the reflected light will be a maximum?
A) Much less than λ **B)** λ/4 **C)** λ/2 **D)** 3λ/4 **E)** λ

___ **6.** In a Young's double-slit experiment, the slit separation is doubled. To maintain the same fringe spacing on the screen, the screen-to-slit distance D must be changed to:
A) $D/2$ **B)** $D/\sqrt{2}$ **C)** $D\sqrt{2}$ **D)** $2D$ **E)** $4D$

___ **7.** If two light waves are coherent:
A) their amplitudes are the same
B) their frequencies are the same
C) their wavelengths are the same
D) their phase difference is constant
E) the difference in their frequencies is constant

___ **8.** Waves from two slits are in phase at the slits and travel to a distant screen to produce the third side maximum of the interference pattern. The difference in the distance traveled by the waves is:
A) half a wavelength
B) a wavelength
C) three halves of a wavelength
D) two wavelengths
E) three wavelengths

___ **9.** In a Young's double-slit experiment the center of a bright fringe occurs wherever waves from the slits differ in the distance they travel by a multiple of:
A) a fourth of a wavelength
B) a half a wavelength
C) a wavelength
D) three-fourths of a wavelength
E) none of the above

___ **10.** A light wave with an electric field amplitude of E_0 and a phase constant of zero is to be combined with one of the following waves: Which of these combinations produces the greatest intensity?

A) wave A has an amplitude of E_0 and a phase constant of zero
B) wave B has an amplitude of E_0 and a phase constant of π
C) wave C has an amplitude of $2E_0$ and a phase constant of zero
D) wave D has an amplitude of $2E_0$ and a phase constant of π
E) wave E has an amplitude of $3E_0$ and a phase constant of π

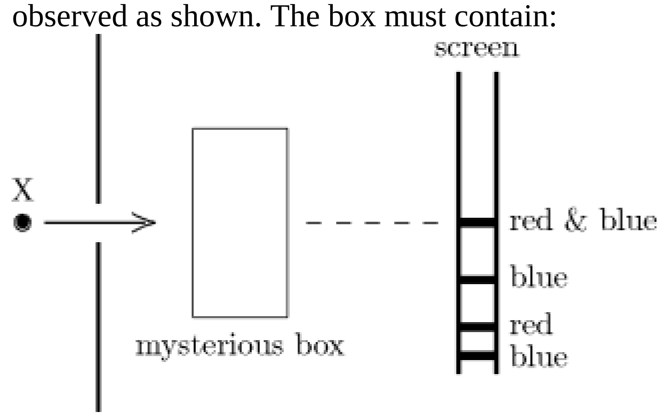
___ **11.** Light from a small region of an ordinary incandescent bulb is passed through a yellow filter and then serves as the source for a Young's double-slit experiment. Which of the following changes would cause the interference pattern to be more closely spaced?

A) Use slits that are closer together
B) Use a light source of lower intensity
C) Use a light source of higher intensity
D) Use a blue filter instead of a yellow filter
E) Move the light source further away from the slits.

___ **12.** In a Young's double-slit experiment, a thin sheet of mica is placed over one of the two slits. As a result, the center of the interference pattern (on the screen) shifts by an amount corresponding to 30 dark bands. The wavelength of the light in this experiment is 480 nm and the index of the mica is 1.60. The mica thickness is:

A) 0.090 mm **B)** 0.012 mm **C)** 0.014 mm **D)** 0.024 mm **E)** 0.062 mm

___ **13.** Light from a point source X contains only blue and red components. After passing through a mysterious box, the light falls on a screen. Bright red and blue hands are observed as shown. The box must contain:



A) a lens **B)** a mirror **C)** a prism **D)** a double slit **E)** a blue and red filter

___ **14.** In a Young's double-slit experiment the center of a bright fringe occurs wherever waves from the slits differ in phase by a multiple of:
A) $\pi/4$ **B)** $\pi/2$ **C)** π **D)** $3\pi/4$ **E)** 2π

___ **15.** A “wave front” is a surface of constant:
A) phase **B)** frequency **C)** wavelength **D)** amplitude **E)** speed

___ **16.** In a Young's double-slit experiment, light of wavelength 500 nm illuminates two slits that are separated by 1 mm. The separation between adjacent bright fringes on a screen 5 m from the slits is:
A) 0.10 cm **B)** 0.25 cm **C)** 0.50 cm **D)** 1.0 cm **E)** none of the above

___ **17.** The phase difference between the two waves that give rise to a dark spot in a Young's double-slit experiment is (where m = integer):
A) zero **B)** $2\pi m + \pi/8$ **C)** $2\pi m + \pi/4$ **D)** $2\pi m + \pi/2$ **E)** $2\pi m + \pi$

___ **18.** Waves from two slits are in phase at the slits and travel to a distant screen to produce the second minimum of the interference pattern. The difference in the distance traveled by the waves is:
A) half a wavelength
B) a wavelength
C) three halves of a wavelength
D) two wavelengths
E) five halves of a wavelength

___ **19.** In a Young's double-slit experiment, the slit separation is doubled. This results in:
A) an increase in fringe intensity
B) a decrease in fringe intensity
C) a halving of the wavelength
D) a halving of the fringe spacing
E) a doubling of the fringe spacing

___ **20.** In a Young's double-slit experiment, it is essential that the two beams:
A) have exactly equal intensity
B) be exactly parallel
C) travel equal distances
D) come originally from the same source
E) be composed of a broad band of frequencies

Answer Key

1. A
   Origin: Chapter 36- Interference, 18
2. D
   Origin: Chapter 36- Interference, 33
3. D
   Origin: Chapter 36- Interference, 22
4. D
   Origin: Chapter 36- Interference, 32
5. B
   Origin: Chapter 36- Interference, 27
6. D
   Origin: Chapter 36- Interference, 14
7. D
   Origin: Chapter 36- Interference, 39
8. E
   Origin: Chapter 36- Interference, 10
9. C
   Origin: Chapter 36- Interference, 8
10. C
    Origin: Chapter 36- Interference, 21
11. D
    Origin: Chapter 36- Interference, 13
12. D
    Origin: Chapter 36- Interference, 24
13. D
    Origin: Chapter 36- Interference, 25
14. E
    Origin: Chapter 36- Interference, 9
15. A
    Origin: Chapter 36- Interference, 1
16. B
    Origin: Chapter 36- Interference, 15
17. E
    Origin: Chapter 36- Interference, 19
18. C
    Origin: Chapter 36- Interference, 11
19. D
    Origin: Chapter 36- Interference, 17
20. D
    Origin: Chapter 36- Interference, 20

Name: ___________________________ Date: _____________

___ **1.** If we increase the wavelength of the light used to form a double-slit diffraction pattern:
A) the width of the central diffraction peak increases and the number of bright fringes within the peak increases
B) the width of the central diffraction peak increases and the number of bright fringes within the peak decreases
C) the width of the central diffraction peak decreases and the number of bright fringes within the peak increases
D) the width of the central diffraction peak decreases and the number of bright fringes within the peak decreases
E) the width of the central diffraction peak increases and the number of bright fringes within the peak stays the same

___ **2.** When a highly coherent beam of light is directed against a very fine wire, the shadow formed behind it is not just that of a single wire but rather looks like the shadow of several parallel wires. The explanation of this involves:
A) refraction
B) diffraction
C) reflection
D) the Doppler effect
E) an optical illusion

___ **3.** A diffraction grating of width W produces a deviation θ in second order for light of wavelength λ. The total number N of slits in the grating is given by:
A) $2W\lambda/ \sin\theta$ **B)** $(W/\lambda) \sin\theta$ **C)** $\lambda W/2 \sin\theta$ **D)** $(W/2\lambda) \sin\theta$ **E)** $2\lambda/ \sin\theta$

___ **4.** The dispersion of a diffraction grating indicates:
A) the resolution of the grating
B) the separation of lines of the same order
C) the number of rulings in the grating
D) the width of the lines
E) the separation of lines of different order for the same wavelength

___ **5.** A student wishes to produce a single-slit diffraction pattern in a ripple tank experiment. He considers the following parameters:
1. frequency
2. wavelength
3. water depth
4. slit width
Which two of the above should be decreased to produce more bending?
A) 1, 3 **B)** 1, 4 **C)** 2, 3 **D)** 2, 4 **E)** 3, 4

___ **6.** At the first minimum adjacent to the central maximum of a single-slit diffraction pattern the phase difference between the Huygens wavelet from the top of the slit and the wavelet from the midpoint of the slit is:
A) $\pi/8$ rad **B)** $\pi/4$ rad **C)** $\pi/2$ rad **D)** π rad **E)** $3\pi/2$ rad

___ **7.** A light beam incident on a diffraction grating consists of waves with two different wavelengths. The separation of the two first order lines is great if:
A) the dispersion is great
B) the resolution is great
C) the dispersion is small
D) the resolution is small
E) none of the above (line separation does not depend on either dispersion or resolution)

___ **8.** Two slits in an opaque barrier each have a width of 0.020 mm and are separated by 0.050 mm. When coherent monochromatic light passes through the slits the number of interference maxima within the central diffraction maximum:
A) is 1
B) is 2
C) is 4
D) is 5
E) cannot be determined unless the wavelength is given

___ **9.** Consider a single-slit diffraction pattern caused by a slit of width a. There is a maximum if $\sin\theta$ is equal to:
A) slightly more than $3\lambda/2a$
B) slightly less than $3\lambda/2a$
C) exactly $3\lambda/2a$
D) exactly $\lambda/2a$
E) very nearly $\lambda/2a$

___ **10.** In a double-slit diffraction experiment the number of interference fringes within the central diffraction maximum can be increased by:
A) increasing the wavelength
B) decreasing the wavelength
C) decreasing the slit separation
D) increasing the slit width
E) decreasing the slit width

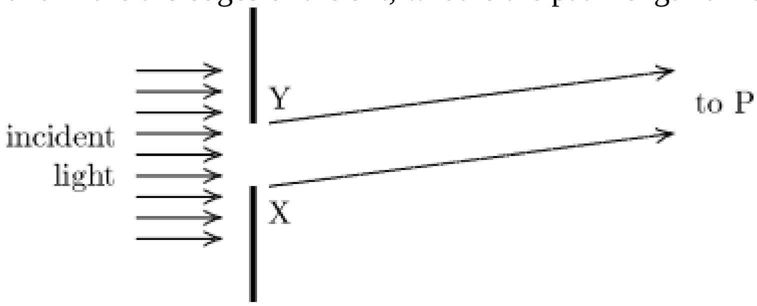
___ **11.** A diffraction grating just resolves the wavelengths 400.0 nm and 400.1 nm in first order. The number of slits in the grating is:
A) 400 **B)** 1000 **C)** 2500 **D)** 4000 **E)** not enough information is given

___ **12.** What is the minimum number of slits required in a diffraction grating to just resolve light with wavelengths of 471.0 nm and 471.6 nm?
A) 99 **B)** 197 **C)** 393 **D)** 786 **E)** 1179

___ **13.** Radio waves are readily diffracted around buildings whereas light waves are negligibly diffracted around buildings. This is because radio waves:
A) are plane polarized
B) have much longer wavelengths than light waves
C) have much shorter wavelengths than light waves
D) are nearly monochromatic (single frequency)
E) are amplitude modulated (AM).

___ **14.** In the equation $\sin\theta = \lambda/a$ for single-slit diffraction, θ is:
A) the angle to the first minimum
B) the angle to the second maximum
C) the phase angle between the extreme rays
D) $N\pi$ where N is an integer
E) $(N + 1/2)\pi$ where N is an integer

___ **15.** The diagram shows a single slit with the direction to a point P on a distant screen shown. At P, the pattern has its second minimum (from its central maximum). If X and Y are the edges of the slit, what is the path length difference (PX) - (PY)?



A) $\lambda/2$ **B)** λ **C)** $3\lambda/2$ **D)** 2λ **E)** $5\lambda/2$

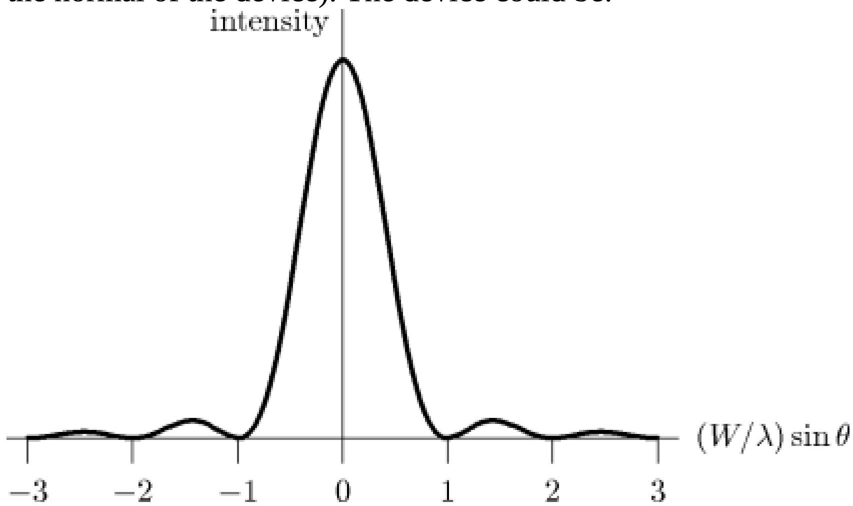
___ **16.** 600-nm light is incident on a diffraction grating with a ruling separation of 1.7×10^{-6} m. The second order line occurs at a diffraction angle of:
A) 0 **B)** 10º **C)** 21º **D)** 42º **E)** 45º

___ **17.** When 450-nm light is incident normally on a certain double-slit system the number of interference maxima within the central diffraction maximum is 5. When 900-nm light is incident on the same slit system the number is:
A) 2 **B)** 3 **C)** 5 **D)** 9 **E)** 10

___ **18.** The rainbow seen after a rain shower is caused by:
A) diffraction **B)** interference **C)** refraction **D)** polarization **E)** absorption

___ **19.** In the equation $\phi = (2\pi a/\lambda) \sin \theta$ for single-slit diffraction, ϕ is:
A) the angle to the first minimum
B) the angle to the second maximum
C) the phase angle between the extreme rays
D) $N\pi$ where N is an integer
E) $(N + 1/2)\pi$ where N is an integer

___ **20.** Light of wavelength λ is normally incident on some plane optical device. The intensity pattern shown is observed on a distant screen (θ is the angle measured from the normal of the device). The device could be:



A) a single slit of width W
B) a single slit of width $2W$
C) two narrow slits with separation W
D) two narrow slits with separation $2W$
E) a diffraction grating with slit separation W

Answer Key

1. E
Origin: Chapter 37- Diffraction, 29
2. B
Origin: Chapter 37- Diffraction, 5
3. D
Origin: Chapter 37- Diffraction, 47
4. B
Origin: Chapter 37- Diffraction, 60
5. B
Origin: Chapter 37- Diffraction, 12
6. D
Origin: Chapter 37- Diffraction, 17
7. A
Origin: Chapter 37- Diffraction, 61
8. D
Origin: Chapter 37- Diffraction, 31
9. B
Origin: Chapter 37- Diffraction, 23
10. E
Origin: Chapter 37- Diffraction, 33
11. D
Origin: Chapter 37- Diffraction, 64
12. C
Origin: Chapter 37- Diffraction, 65
13. B
Origin: Chapter 37- Diffraction, 2
14. A
Origin: Chapter 37- Diffraction, 9
15. D
Origin: Chapter 37- Diffraction, 15
16. E
Origin: Chapter 37- Diffraction, 41
17. C
Origin: Chapter 37- Diffraction, 32
18. C
Origin: Chapter 37- Diffraction, 4
19. C
Origin: Chapter 37- Diffraction, 10
20. A
Origin: Chapter 37- Diffraction, 53

Name: ___________________________ Date: _____________

___ **1.** Two electrons move in opposite directions at $0.70c$ as measured in the laboratory. The speed of one electron as measured from the other is:
A) $0.35c$ **B)** $0.70c$ **C)** $0.94c$ **D)** $1.00c$ **E)** $1.40c$

___ **2.** Visible light, with a frequency of 6.0×10^{14} Hz, is reflected from a spaceship moving directly away at a speed of $0.90c$. The frequency of the reflected waves observed at the source is:
A) 3.2×10^{13} Hz
B) 1.4×10^{14} Hz
C) 6.0×10^{14} Hz
D) 2.6×10^{15} Hz
E) 1.1×10^{16} Hz

___ **3.** Two events occur 100 m apart with an intervening time interval of 0.60 μs. The speed of a reference frame in which they occur at the same coordinate is:
A) 0 **B)** $0.25c$ **C)** $0.56c$ **D)** $1.1c$ **E)** $1.8c$

___ **4.** An electron ($m = 9.11 \times 10^{-31}$ kg) has a momentum of 4.0×10^{-22} kg · m/s. Its kinetic energy is:
A) 6.3×10^{-14} J
B) 8.2×10^{-14} J
C) 1.2×10^{-13} J
D) 1.5×10^{-13} J
E) 2.7×10^{-13} J

___ **5.** The velocity of an electron is changed from $c/2$ in the $-x$ direction to $c/2$ in the $+x$ direction. As a result, its kinetic energy changes by:
A) mc^2 **B)** $0.5mc^2$ **C)** $\sqrt{2}mc^2$ **D)** $2mc^2$ **E)** zero

___ **6.** An electron ($m = 9.11 \times 10^{-31}$ kg) has a speed of $0.95c$. Its kinetic energy is:
A) 8.2×10^{-14} J
B) 1.8×10^{-13} J
C) 2.0×10^{-13} J
D) 2.2×10^{-13} J
E) 2.6×10^{-13} J

___ **7.** The proper time between two events is measured by clocks at rest in a reference frame in which the two events:
A) occur at the same time
B) occur at the same coordinates
C) are separated by the distance a light signal can travel during the time interval
D) occur in Boston
E) satisfy none of the above

___ **8.** A clock is moving along the x axis at $0.6c$. It reads zero as it passes the origin ($x = 0$). When it passes the $x = 180$ m mark on the x axis the clock reads:
A) 0.60 μs **B)** 0.80 μs **C)** 1.00 μs **D)** 1.25 μs **E)** 1.67 μs

___ **9.** Two events occur 100 m apart with an intervening time interval of 0.37 μs. The speed of a clock that measures the proper time between the events is:
A) 0 **B)** $0.45c$ **C)** $0.56c$ **D)** $0.90c$ **E)** $1.8c$

___ **10.** Two events occur on the x axis separated in time by Δt and in space by Δx. A reference frame, traveling at less than the speed of light, in which the two events occur at the same coordinate:
A) exists no matter what the values of Δx and Δt
B) exists only if $\Delta x/\Delta t < c$
C) exists only if $\Delta x/\Delta t > c$
D) exists only if $\Delta x/\Delta t = c$
E) does not exist under any condition

___ **11.** A source at rest emits light of wavelength 500 nm. When it is moving at $0.90c$ away from an observer, the observer detects light of wavelength:
A) 26 nm **B)** 115 nm **C)** 500 nm **D)** 2200 nm **E)** 9500 nm

___ **12.** Two independent events occur 100 m apart with an intervening time interval of 0.42 μs. The proper time in μs between the events is:
A) 0 **B)** 0.16 **C)** 0.26 **D)** 0.42 **E)** 0.69

___ **13.** A train traveling very fast ($v = 0.6c$) has an engineer (E) at the front, a guard (G) at the rear, and an observer (S′) exactly half way between them. Both E and G are equipped with yellow signaling lamps. The train passes a station, closely observed by the station master (S). Both E and G use their lamps to send signals. According to both S and S′ these signals arrive simultaneously at the instant S′ is passing S. According to S′:

A) E and G sent their signals simultaneously from different distances
B) G sent his signal before E and from farther away
C) G sent his signal before E but was the same distance away
D) E sent his signal before G and from farther away
E) none of the above

___ **14.** A basic postulate of Einstein's theory of relativity is:

A) moving clocks run more slowly than when they are at rest
B) moving rods are shorter than when they are at rest
C) light has both wave and particle properties
D) the laws of physics must be the same for observers moving with uniform velocity relative to each other
E) everything is relative

___ **15.** The mass of a particle is m. In order for its total energy to be twice its rest energy, its momentum must be:

A) $mc/2$ **B)** $mc/\sqrt{2}$ **C)** mc **D)** $\sqrt{3}mc$ **E)** $2mc$

___ **16.** A meson moving through a laboratory of length x at a speed v decays after a lifetime T as measured by an observer at rest in the laboratory. If the meson were at rest in the laboratory its lifetime would be:

A) $T(1-v/c)$
B) $T(1-v/c)^{-1}$
C) $T(1-v^2/c^2)^{-1/2}$
D) $T(1-v^2/c^2)^{1/2}$
E) $(T-vx/c^2)(1-v^2/c^2)^{-1/2}$

___ **17.** If the kinetic energy of a particle is equal to its rest energy then its speed must be:

A) $0.25c$ **B)** $0.50c$ **C)** $0.87c$ **D)** c **E)** unknown unless its mass is given

___ **18.** According to the special theory of relativity:

A) all forms of energy have mass-like properties
B) moving particles lose mass
C) momentum is not conserved in high speed collisions
D) a rod moving rapidly sideways is shorter along its length
E) a rod moving rapidly sideways is longer along its length

___ **19.** Two flashes of light occur simultaneously at $t = 0$ in reference frame S, one at $x = 0$ and the other at $x = 600$ m. They are observed in reference frame S′, which is moving at $0.95c$ in the positive x direction. The origins of the two frames coincide at $t = 0$ and the clocks of S′ are zeroed when the origins coincide. In S′ the coordinate where the leading edges of the two light flashes meet and the time when they meet are:

A) 300 m, 1.0 μs
B) 15 m, 0.050 μs
C) 585 m, 1.95 μs
D) 49 m, 0.16 μs
E) 1900 m, 0.16 μs

___ **20.** A source at rest emits light of wavelength 500 nm. When it is moving at $0.90c$ toward an observer, the observer detects light of wavelength:

A) 26 nm **B)** 115 nm **C)** 500 nm **D)** 2200 nm **E)** 9500 nm

Answer Key

1. C
   Origin: Chapter 38- Special Relativity, 38
2. A
   Origin: Chapter 38- Special Relativity, 47
3. C
   Origin: Chapter 38- Special Relativity, 15
4. A
   Origin: Chapter 38- Special Relativity, 64
5. E
   Origin: Chapter 38- Special Relativity, 51
6. B
   Origin: Chapter 38- Special Relativity, 53
7. B
   Origin: Chapter 38- Special Relativity, 8
8. B
   Origin: Chapter 38- Special Relativity, 30
9. D
   Origin: Chapter 38- Special Relativity, 17
10. B
    Origin: Chapter 38- Special Relativity, 12
11. D
    Origin: Chapter 38- Special Relativity, 46
12. C
    Origin: Chapter 38- Special Relativity, 16
13. E
    Origin: Chapter 38- Special Relativity, 7
14. D
    Origin: Chapter 38- Special Relativity, 1
15. D
    Origin: Chapter 38- Special Relativity, 56
16. D
    Origin: Chapter 38- Special Relativity, 22
17. C
    Origin: Chapter 38- Special Relativity, 57
18. A
    Origin: Chapter 38- Special Relativity, 55
19. D
    Origin: Chapter 38- Special Relativity, 34
20. B
    Origin: Chapter 38- Special Relativity, 45