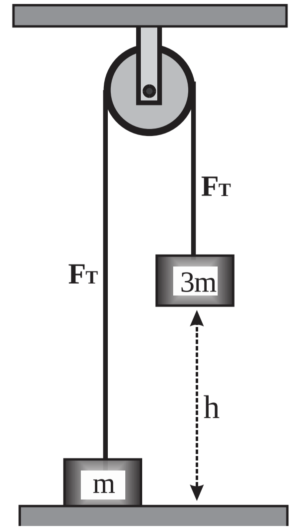
NJSL Physics C January Exam 2013

DIRECTIONS: Please PRINT your name, school, area, and which test you are taking on the Scantron supplied. For each statement or question, completely fill in the appropriate space on the answer sheet. Use the letter preceding the word or phrase or sketch which best completes the statement or answers the question. Unless stated otherwise assume ideal conditions including no friction with the air and that the magnitude of the acceleration of gravity is g = 9.8 m/s^2. Sketches are not to scale.



Two masses are attached to the opposite ends of a string which is hung over a pulley as shown to the right. The masses of the string and pulley are insignificant. The larger mass is three times the mass of the smaller mass m. The larger mass is released from rest and is allowed to fall a distance h to the floor below.

1. What will be the tension F_T in the string as the larger mass accelerates to the floor?
   A. 2·mg B. 3·mg C. 4·mg D. mg/2 E. 3·mg/2

2. What will be the kinetic energy of the larger mass as it reaches the floor?
   A. 2·mgh B. 3·mgh C. 4·mgh D. mgh/2 E. 3·mgh/2

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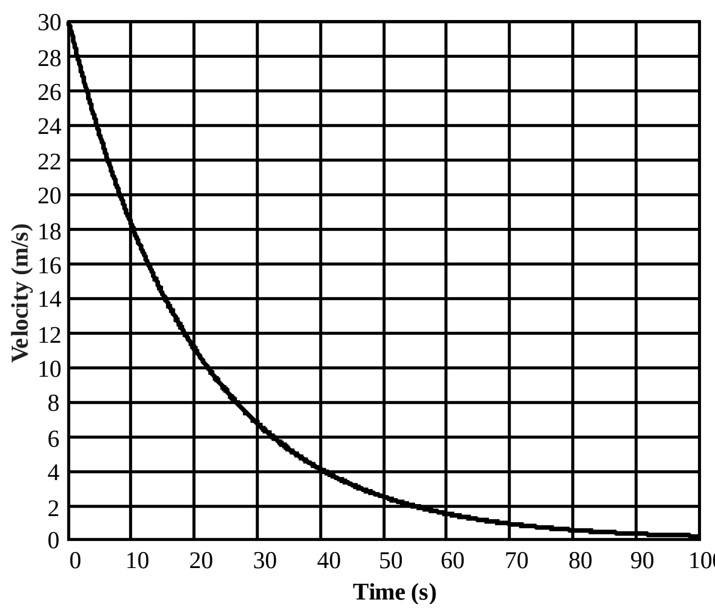
3. A mass **m** is moving up an inclined plane, which meets the horizontal at an angle α and has a coefficient of kinetic friction μ, with a constant acceleration **a**. What magnitude force **F** must you apply to this mass in order to maintain this constant acceleration?
   A. $2\cdot m\cdot g\cdot[\cos(\alpha) + \mu\cdot\sin(\alpha)]$ B. $m\cdot g\cdot[\sin(\alpha) - \mu\cdot\cos(\alpha)]-m\cdot a$ C. $m\cdot[g\cdot\sin(\alpha) + \mu\cdot g\cdot\cos(\alpha) + a]$
   D. $m\cdot g\cdot[\cos(\alpha) - \mu\cdot\sin(\alpha)] + m\cdot a$ E. $m\cdot g\cdot\sin(\alpha) - m\cdot\mu\cdot g\cdot\cos(\alpha) - m\cdot a$

4. A particle moves along the x-axis with a non-constant acceleration described by a = 30·t, where a is in meters per second squared and t is in seconds. If the particle starts with an initial velocity of -40 m/s and an initial displacement of 100m at t = 0s, where will the particle be when t = 5 seconds?
   A. 625m B. 410m C. 925m D. 525m E. 455m

5. A satellite moves in a stable, circular orbit with speed $\mathbf{v_o}$ at a distance **R** from the center of a planet. For this satellite to move in a stable, circular orbit at a distance **4·R** from the center of the planet, the speed of the satellite must be ______________.
   A. $\sqrt{2}\cdot v_o$ B. $v_o/\sqrt{2}$ C. v_o D. $v_o/2$ E. $2\cdot v_o$

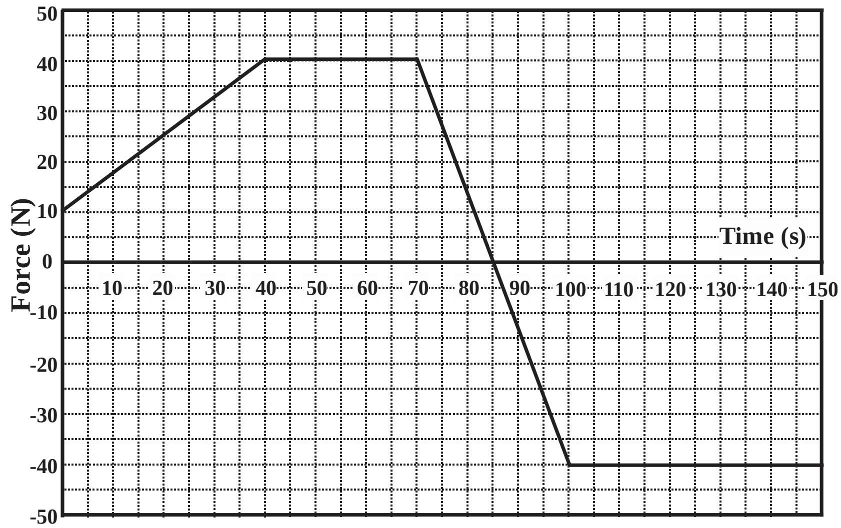


A car which has a mass of 2000kg is moving along a level road with a velocity of 30m/s when the engine stalls. The driver immediately throws the car into neutral and the car gradually coasts to a halt under the influence of a drag force given by the relationship: $F_d = -b\cdot v$ where b is the drag coefficient and v is the instantaneous velocity of the car as shown on the graph to the right.

6. What is the magnitude of the drag coefficient **b** of this car as it slows to a halt?
   A. 100kg/s B. 30kg/s C. 20kg/s
   D. 15kg/s E. 10kg/s

7. How far does the car move from the time the engine stalls until the car comes to rest?
   A. 130m B. 600m C. 1150m
   D. 1430m E. 1660m

A 50 kg mass is moving towards the left with a velocity of -8.0 m/s when a variety of forces are sequentially applied to the mass over a time period of 150 seconds as shown on the graph to the right.



8. What will be the impulse delivered to this mass during the first 70 seconds?
   A. 2000 kg·m/s B. 1200 kg·m/s
   C. 2200 kg·m/s D. 800 kg·m/s
   E. 400 kg·m/s

9. What will be the velocity of the mass at the end of 150 seconds?
   A. 12 m/s B. -4.0 m/s C. 16 m/s
   D. 8.0 m/s E. -12 m/s

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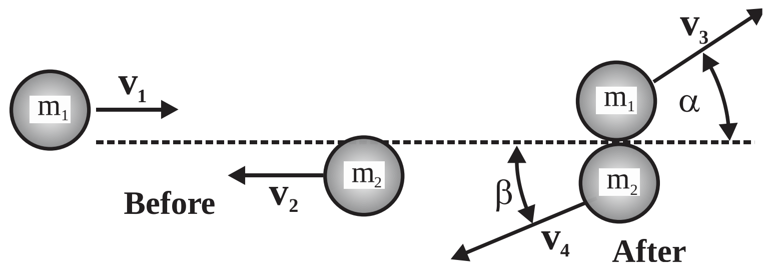
A mass of m_1 = 8.0 kg is moving towards the right with a velocity v_1 = 6.0 m/s when it has a grazing collision with a mass of m_2 = 2.0 kg moving towards the left with a velocity of v_2 = -4.0 m/s. After the collision the first mass is deflected at an angle of $\alpha = 5.2^o$ relative to its original direction of motion with a new velocity of v_3 = 5.95 m/s while the second mass is deflected to the left of its original path of motion at an angle of $\beta = 30.2^o$.



10. What will be the total momentum of this system immediately after the collision?
   A. 62 kg·m/s B. 18 kg·m/s C. -44 kg·m/s D. 40 kg·m/s E. 0.0 kg·m/s

11. What will be the magnitude of the final velocity v_4 of mass m_2 immediately after the collision?
   A. 12.0 m/s B. 8.2 m/s C. 4.3 m/s D. 3.1 m/s E. 2.2 m/s

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A sled and rider, which have a combined mass m, are being pulled towards the left by force F which is being applied to a rope tied to the front of the sled at an angle of α above the horizontal. The coefficient of sliding friction between the sled and the ground is μ and as a result the sled moves towards the left at a constant speed of v_o.

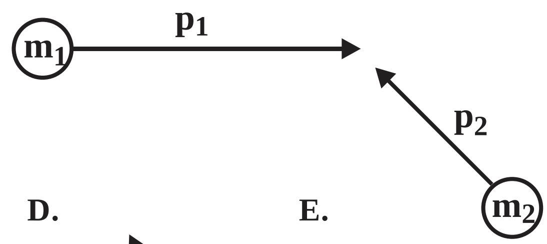
12. What will be the magnitude of the normal force acting on the sled as it is pulled to the left at this constant speed v_o?
   A. $m \cdot g \cdot \sin(\alpha)$ B. $m \cdot g \cdot \mu \cdot \cos(\alpha)$ C. $m \cdot g - F \cdot \sin(\alpha)$ D. $m \cdot g + F \cdot \cos(\alpha)$ E. $m \cdot g$

13. Which of the following equations correctly determines the force F acting this sled as it moves towards the left at a constant speed?
   A. $F = m \cdot g/\sin(\alpha)$ B. $F = m \cdot g \cdot \mu/[\cos(\alpha)+\mu \cdot \sin(\alpha)]$ C. $F = 2 \cdot m \cdot g \cdot [\sin(\alpha)-\mu \cdot \cos(\alpha)]$
   D. $F = m \cdot g \cdot \mu \cdot [\sin(\alpha)+\cos(\alpha)]$ E. $m \cdot g \cdot [\sin(\alpha)-\mu \cdot \cos(\alpha)]$

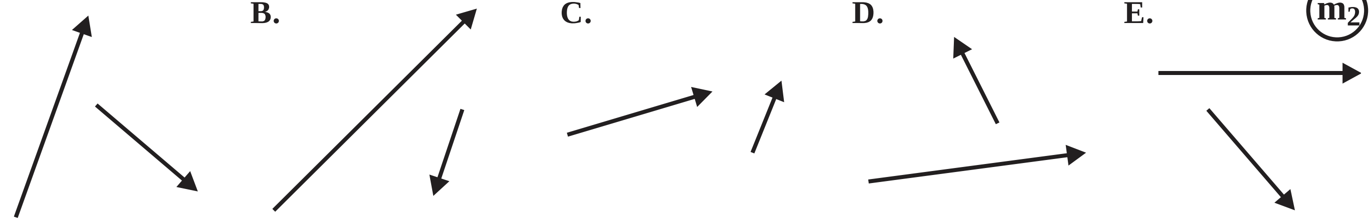
Suppose that the sled is accelerated until it is moving towards the left at a new constant velocity $3 \cdot v_o$.

14. How much force will be required to pull the sled towards the left at this new velocity?
   A. F B. 2·F C. 3·F D. F/3 E. 6·F

15. Two objects, m_1 and m_2, are moving with momentums, p_1 and p_2, as shown to scale in the diagram to the right. Which of the following sets of momentum vectors **cannot** represent the momentums of the two objects after the collision?

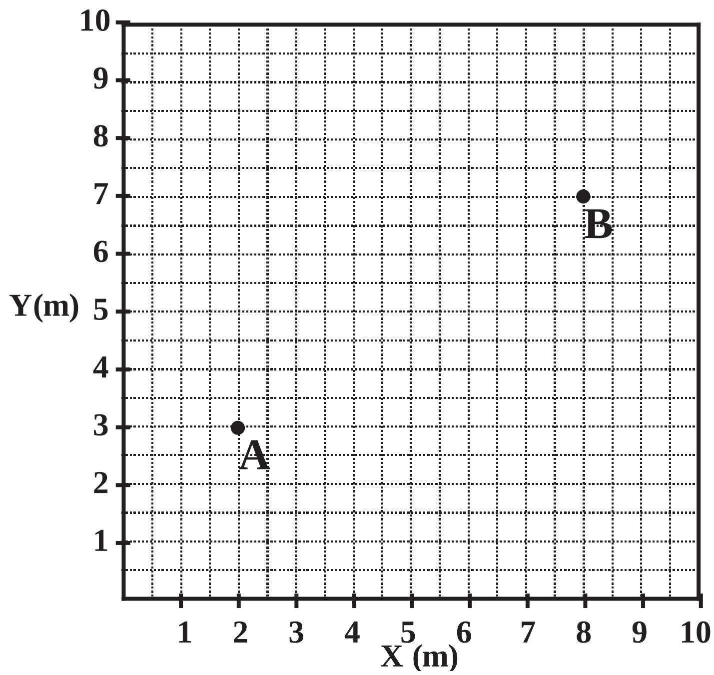


A. **B.** **C.** **D.** **E.**



A mass M is located at point A in an area of space, as shown to the right, where it feels a force F given by:

F = (8$\hat{\imath}$ - 3$\hat{\jmath}$) N

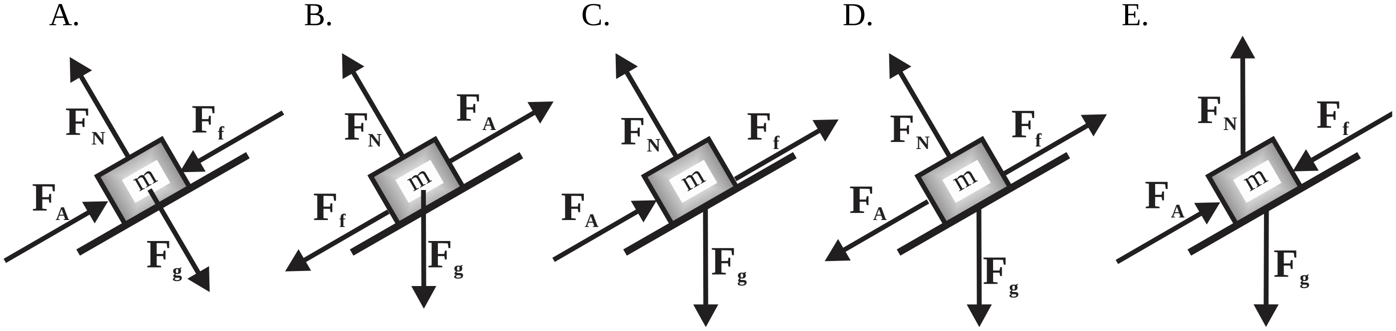


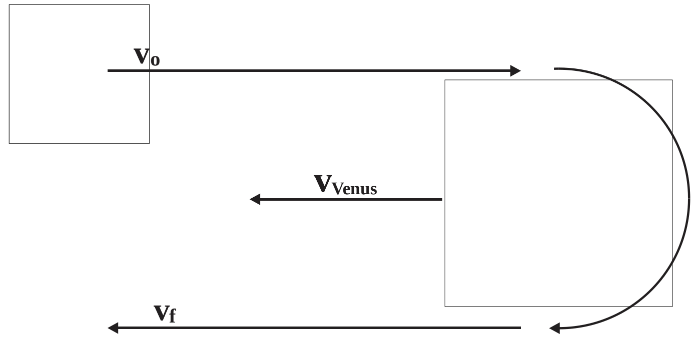
16. How much work will be done on this mass **M** in moving it from point **A** to point **B**?
A. 24 J B. 12 J C. 184 J
D. 36 J E. 108 J

A mass M sitting on a horizontal frictionless surface is connected to a spring which has a spring constant k and which follows Hooke's Law. The mass is displaced a distance X from equilibrium and is then released resulting in the mass oscillating back and forth about the equilibrium point.

17. What will be the kinetic energy of the mass M when it is X/2 from the equilibrium point?
A. $\frac{3}{8}\cdot k\cdot X^2$ B. $\frac{1}{8}\cdot k\cdot X^2$ C. $\frac{1}{4}\cdot k\cdot X^2$ D. $\frac{3}{4}\cdot k\cdot X^2$ E. $\frac{1}{16}\cdot k\cdot X^2$

18. Which of the following free body diagrams correctly depicts all of the forces acting on a mass **m** as it accelerates up an inclined plane at a constant rate?
A. B. C. D. E.





19. The Venera space probe, which has a mass of 960kg, is moving towards the planet Venus with a velocity of V_o = 14.2 km/s. Venus, which has a mass of 4.87 x 10^{24} kg, is moving in the opposite direction with an orbital velocity of V_{Venus} = 35.6 km/s. The space probe performs a frictionless gravitational flyby maneuver with Venus and ultimately moves off in the direction opposite its initial approach as shown to the right. What will be the velocity V_f of the space craft after its interaction with Venus?
    A. 14.2 km/s B. 85.4 km/s C. 44.4 km/s D. 21.4 km/s E. 17.4 km/s

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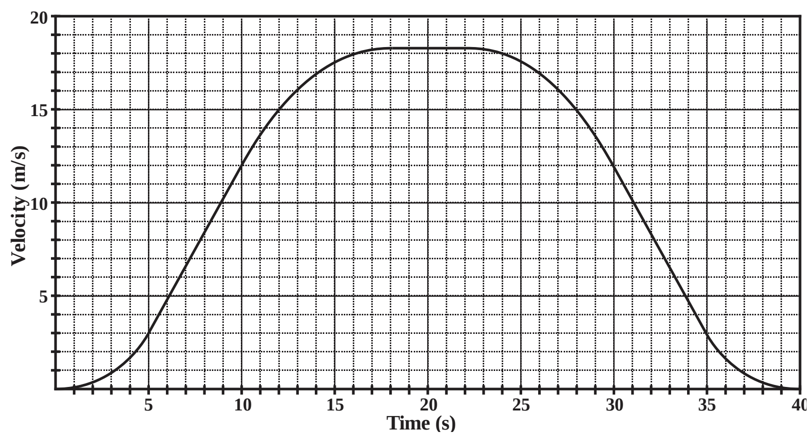
A passenger, who has a mass of 50 kg, is standing on a bathroom scale on an elevator which has a velocity as a function of time as given by the graph to the right.



20. What will be the reading on the scale when t = 8.0 seconds?
    A. 500 N B. 400 N C.550 N
    D. 720 N E. 580 N

21. During which of the following time intervals is the acceleration of the elevator increasing?
    A. 5-10 s B. 10-15 s C. 15-20 s
    D. 25-30 s E. 35-40 s

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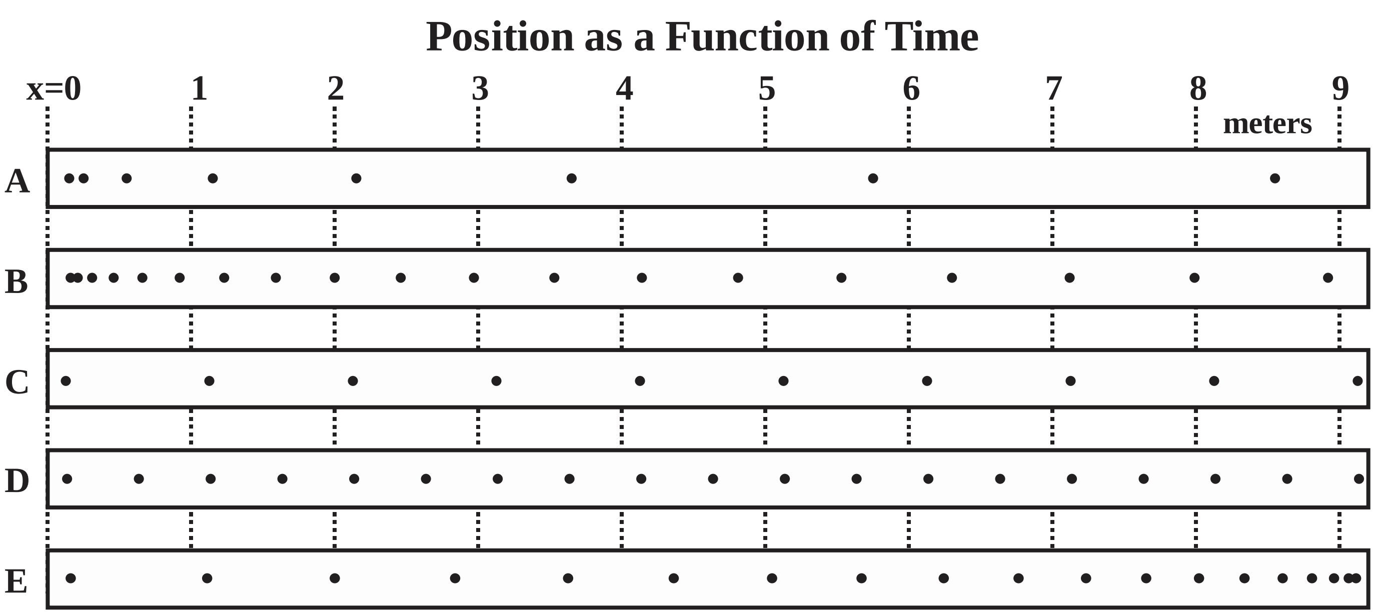
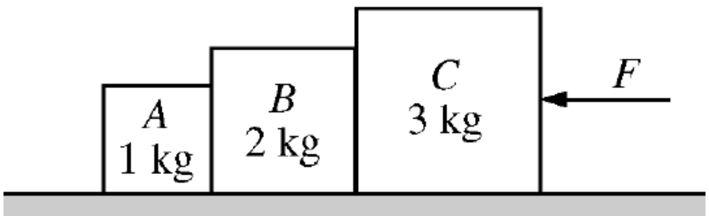
22. Each of the images below is a record of the position of a moving object as a function of time. The time interval between any pair of adjacent dots is the same Δt. In which image is the acceleration of the object negative?



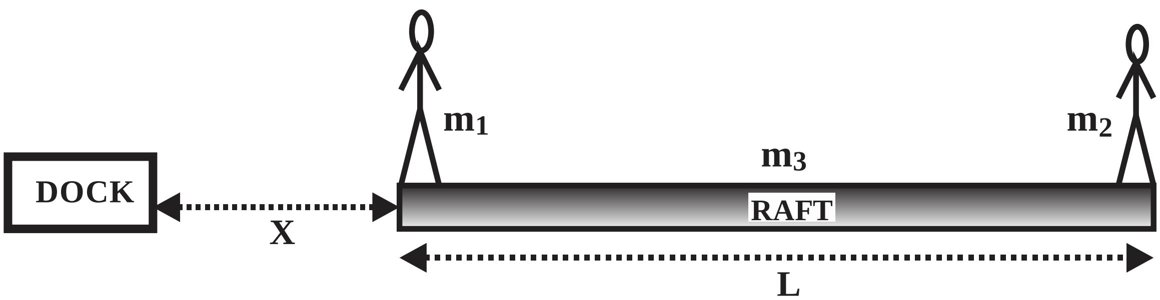
23. A crate is being accelerated upward by a rope attached to an electric winch mounted on the ledge of a building. Assuming that the tension being applied to the crate by the rope is the action force, which of the following forces is the reaction force in accordance with Newton's 3rd Law?
   A. The force of gravity on the box.
   B. The force of tension being applied by the winch to the rope.
   C. The force of friction between the rope and the axle of the winch.
   D. The tension being applied to the rope by the accelerating box.
   E. The normal force between the winch and the building ledge on which it sits.



A force F is applied to three boxes, as shown above, so as to accelerate the boxes to the left with an acceleration a.

24. What will be the direction and magnitude of the force acting on box B by box A?
   A. 2/3 F left   B. 1/3 F right   C. 1/6 F right   D. 1/3 F left   E. 1/6 F left

A raft, which has a mass of m_3 = 30kg and a length of L = 8.0m, is sitting a distance X = 2.0 m from the end of a dock as shown below. On the left end of the raft stands a passenger with a mass of m_1 = 120 kg while on the right end of the raft stands a second passenger with a mass m_2 = 60 kg.



25. How far from the end of the dock is the center of mass of the system consisting of the raft and the two passengers?
   A. 4.9 m   B. 5.2 m   C. 5.4 m   D. 4.2 m   E. 6.1 m

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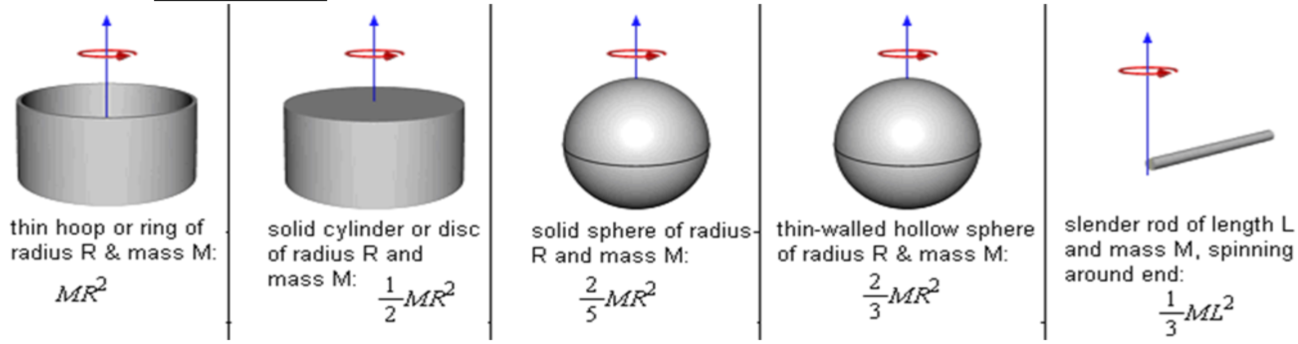
Answer Key

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

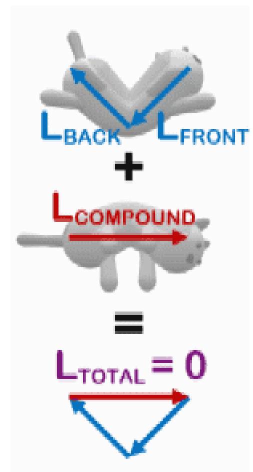
AP Physics C February 14, 2013 Exam

DIRECTIONS: Please PRINT your name, school, area, and which test you are taking on the scantron supplied. Assume <u>g = 10 m/s²</u> and the following moments of inertia:



1. A cat dropped upside down (without any initial rotation) lands upright. Assume that a cat accomplishes this by bending its body and turning the front half and the back half at equal angular speeds with respect to axes of rotation at 90° to each other. The diagram shows the individual angular momenta of the front, L_{front}, and the back, L_{back}, parts of a falling cat's body and the angular momentum, $L_{compund}$, of the whole (compound) cat. Estimate the **angular speed** of **<u>each half</u>** of the body the cat needs to land upright from a height of one meter. (Assume the cat is in free fall.)

   A . 1.6 rad/s **B.** 3.1 rad/s **C.** 4.5 rad/s **D.** 8.9 rad/s **E.** 9.9 rad/sec



2. A cannon ball of mass, m, is shot at 45° to the horizontal with a speed, v. What is the magnitude of the change in the cannon ball's angular momentum relative to the cannon from the time it leaves the barrel to the time it reaches the maximum height?

   A. $\Delta L = 0$ because gravitational force doesn't apply a torque on the cannon ball

   B. $\Delta L = \frac{mv^3}{4g\sqrt{2}}$ **C.** $\Delta L = \frac{mv^2}{2g}$ **D.** $\Delta L = \frac{mv^3\sqrt{2}}{g}$ **E.** $\Delta L = 2mv$

3. Two pendulums are used in a lab experiment. One pendulum consists of a long string, length L and a small mass at the end, M. Another pendulum consists of a solid rod of a length, L, and mass, M, suspended from its end. The period of the mass on a string is measured to be 1.0 sec. What is the period of small oscillations of the rod?

   A . 0.50 sec **B.** 0.67 sec **C.** 0.82 sec **D.** 1.0 sec **E.** 1.52 sec

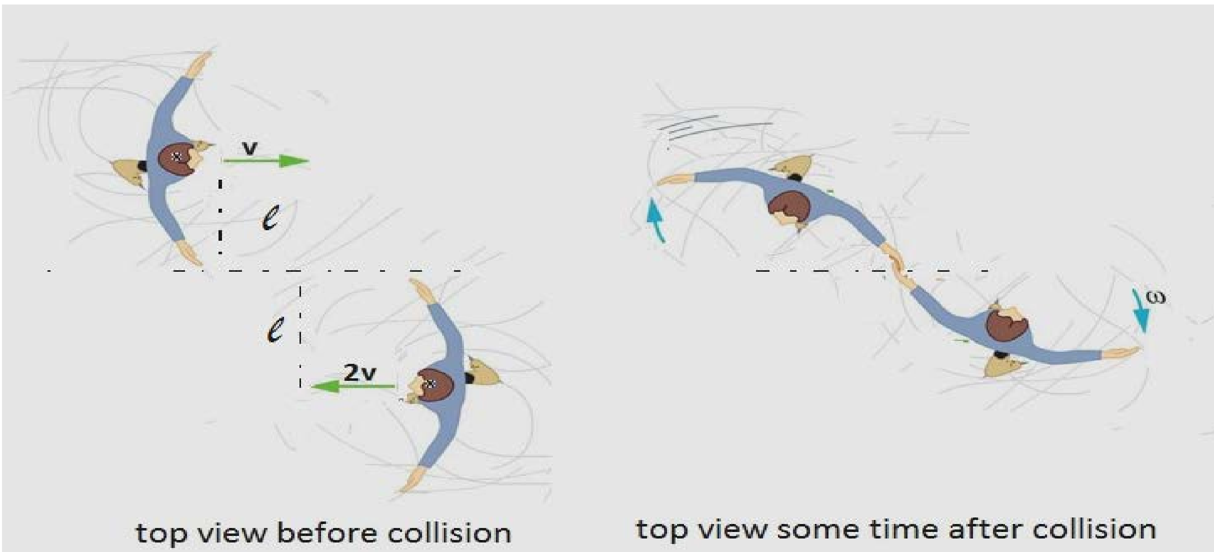
4. The moment of inertia of a solid uniform sphere is given by the expression, $\frac{2}{5}MR^2$. The measured moment of inertia of Earth is given by the expression, $0.34MR^2$, where M is the total mass and R is the radius of Earth. Which of the following could be true based on this result?

   A. Earth has uniform density, but its shape is flatter, slightly closer to that of a disk.
   B. Earth has a thick heavy crust and less dense interior.
   C. Earth is a hollow uniform solid spherical shell with the outer radius, R, and the inner radius, R/2.
   D. Earth is a uniform solid sphere.
   E. Earth's density increases toward its center.

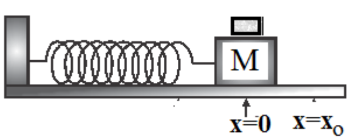
5. Twins, each of a mass, m, are skating toward each other with parallel velocities, with their centers of mass at a distance twice an arm length, ℓ, from each other. The velocity of one skater is v to the right, and the velocity of the other is **-2v** to the left. Upon reaching each other, the twins hold hands and spin together with their arms still outstretched as shown. Find the angular speed, **ω**, of the twins and the velocity of the center of mass, $\mathbf{v_{cm}}$, after collision.

A. $\omega = \frac{v}{\ell}$; $v_{cm} = v$ **B.** $\omega = \frac{3v}{2\ell}$; $v_{cm} = -\frac{v}{2}$ **C.** $\omega = \frac{2v}{\ell}$; $v_{cm} = -v$

D. $\omega = \frac{2v}{3\ell}$; $v_{cm} = -\frac{v}{2}$ **E.** $\omega = \frac{2v}{\ell}$; $v_{cm} = 0$



6. Johannes Keppler's Law of Areas for planetary motion is a consequence of which law of nature?
   A. The Law of Conservation of Angular Momentum
   B. The Law of Conservation of Energy
   C. The Law of Conservation of Linear Momentum
   D. Newton's Second Law
   E. The Third Law of Thermodynamics.



7. A block of a mass, **M**, is attached to a spring with a spring constant, **k**, and oscillates on a frictionless, horizontal surface. A small mass, **m**, is placed on top of the block. The coefficient of static friction between the block and the mass is μ_s. The block and mass oscillate together with an amplitude $\mathbf{x_o}$. Find the maximum amplitude such that the mass m doesn't slip:

A . $x_o = \frac{\mu_s g M}{k}$ **B.** $x_o = \frac{\mu_s g(m+M)}{k}$ **C.** $x_o = \frac{\mu_s g}{k}$ **D.** $x_o = \frac{m+M}{k}$ **E.** $x_o = \frac{k(m+M)}{\mu_s g}$

8. A block of a mass, **M**, is attached to a spring with a spring constant, **k**, and oscillates on a horizontal surface. A damping force F = -bv acts on the mass. How long (in seconds) does it take for the amplitude of the oscillations to decrease by a factor of 2?

A . $\frac{2m\cdot\ln(2)}{b}$ B. $\frac{2b\cdot\ln(2)}{m}$ C. $\frac{2m}{b}$ D. $\frac{b}{2m}$ E. $2\ln(2)$

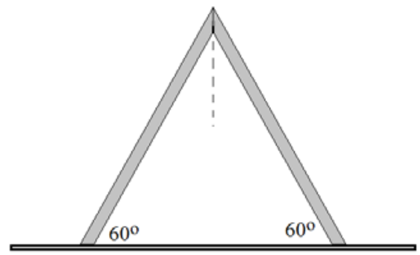
9. A block of a mass, **M**, is attached to a spring with a spring constant, **k**, and oscillates on a horizontal surface. A damping force F = -bv acts on the mass. If pushed by a periodic outside force F = $F_o\cos(\omega t)$, the block on a spring will resonate at an angular frequency:

A . $\omega = \sqrt{\frac{k}{m}}$ B. $\omega < \sqrt{\frac{k}{m}}$ C. $\omega > \sqrt{\frac{k}{m}}$ D. $\omega < \sqrt{\frac{m}{k}}$ E. resonance will not occur

10. A v-shaped step ladder with a total mass of 20 kg, is made of two equal and uniform pieces. The ladder is standing on the floor in equilibrium when each leg forms a 60° angle to the horizontal. What is the friction force applied on each leg by the floor?

A . 29 N B. 34 N C. 14 N D. 38 N

E . It is impossible to find the friction force without the coefficient of friction

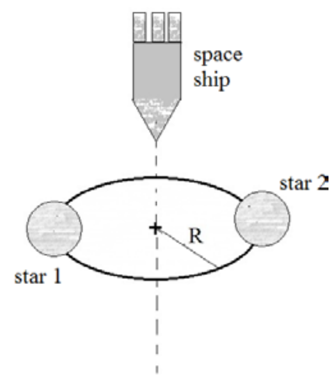


11. A log in the shape of a solid uniform cylinder rolls from rest without slipping down a hill of a height H. When the log reaches the bottom of the hill, what percent of its original potential energy is converted to rotational kinetic energy?

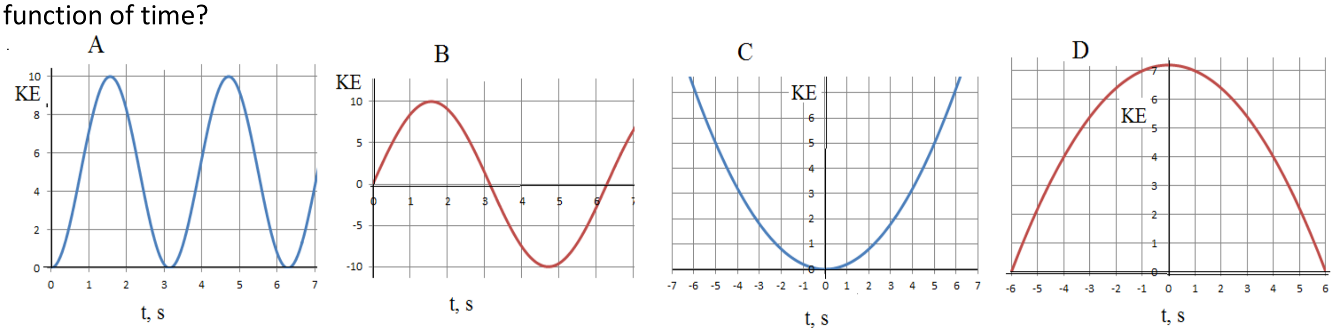
A . 25% **B.** 33% **C.** 50% **D.** 67% **E.** 75%

12. Flying your newest model space ship you are approaching a double star system. Each star has a mass M. The stars are orbiting their common center of mass at a distance R from the center of mass. If you pass through the system's center of mass perpendicular to their orbital plane, what minimum speed must you have at the center of mass if you are to escape to "infinity" from the two-star system (and continue on to other destinations)?

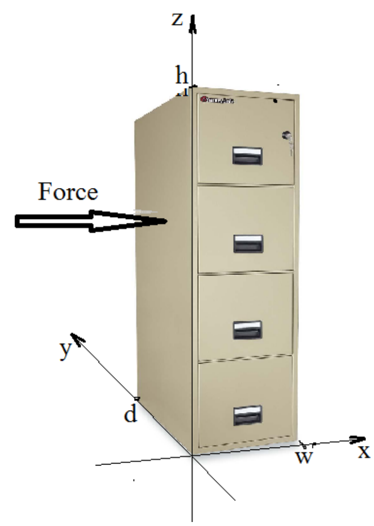
A . $\sqrt{\frac{GM}{R}}$ **B.** $\sqrt{\frac{2GM}{R}}$ **C.** $\sqrt{\frac{3GM}{R}}$ **D.** $\sqrt{\frac{4GM}{R}}$ **E.** $\sqrt{\frac{GM}{2R}}$



13. Assume that the potential energy of an object of mass m is given as a function of the object's position by the function $U = ax^2$. The object is displaced from its equilibrium position and released. Which of the following represents the kinetic energy of the same object as a function of time?



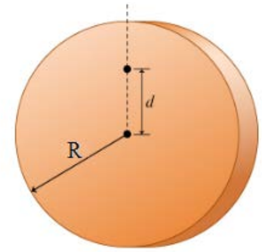
14. A 500 N file cabinet is initially at rest on a level floor. Consider the density of the cabinet to be uniform. The coefficient of friction between the cabinet and the floor is μ_s = 0.6. The width, height, and depth of the cabinet are respectively, w=40 cm and h=160 cm, and d=60 cm. An x-y-z coordinate system is positioned as shown. A force, F=$\langle 250\ N, 0, 0\rangle$ is applied at a point (0, 30 cm, 100 cm). Which of the following is correct for this situation?
    A. The cabinet accelerates along the floor and tips over rotating around its bottom right edge.
    B. The cabinet remains balanced translationally and rotationally.
    C. The cabinet remains at rest translationally but tips over rotating around its bottom right edge.
    D. The cabinet accelerates along the floor, but remains balanced in the upright position.
    E. The problem cannot be solved without knowing the coefficient of kinetic friction.



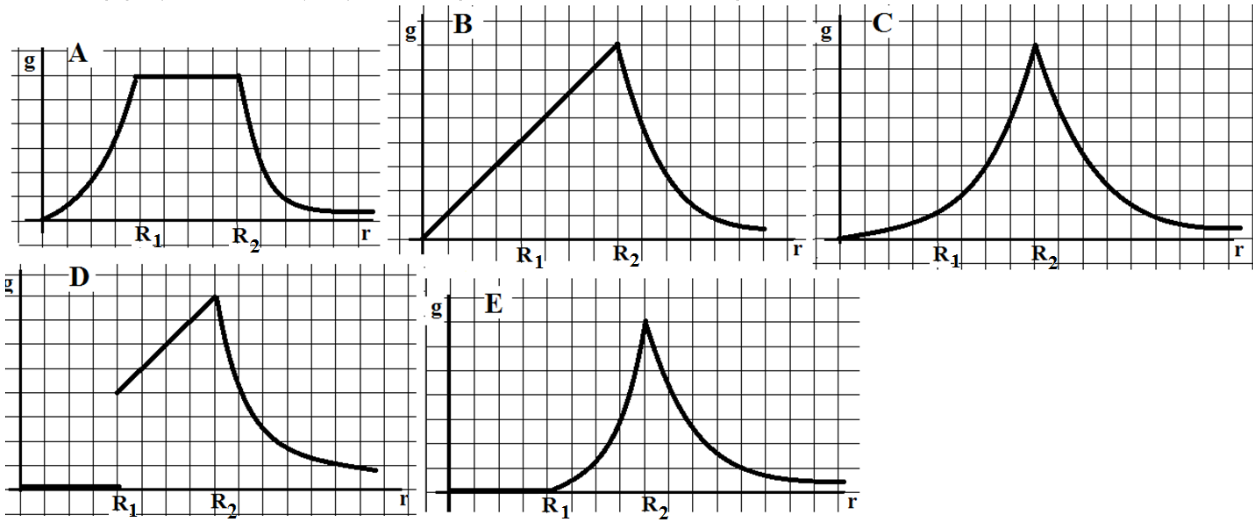
15. The total angular momentum of a system of particles remains the same if and only if
    A. The net outside torque acting on the system is zero.
    B. The net resultant of all outside forces is equal to zero
    C. The total energy in the system remains the same
    D. Both A and B must be true
    E. A, B, and C must be true

16. A spinning flywheel stores 10^3 J rotational kinetic energy. If the flywheel has a moment of inertia of $2x10^3$ kgm^2, what is its angular momentum?
    A . $4x10^2 \frac{kgm^2}{s}$ B. $8x10^2 \frac{kgm^2}{s}$ C. $1x10^3 \frac{kgm^2}{s}$ D. $2x10^3 \frac{kgm^2}{s}$ E. $4x10^3 \frac{kgm^2}{s}$

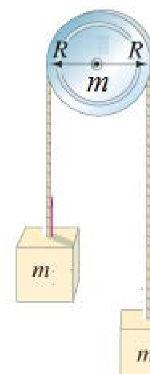
17. A disk of a radius R is suspended as a physical pendulum from a point distance d from its center. What value of d results in the shortest possible period?
    A . R   B. $\frac{R}{2}$ C. $\frac{2R}{3}$ D. $\frac{R}{\sqrt{2}}$ E. 0



18. A thick spherical shell has the inner radius $\mathbf{R_1}$ and the outer radius $\mathbf{R_2}$. Assume that the density of the material is uniform within the shell. The mass of the shell is M. Which of the following graphs correctly represents gravitational field strength inside and outside of the shell?



19. Two identical blocks, each of mass m, are hanging in equilibrium over a pulley of mass, ***m***. The pulley is in the shape of a solid cylinder. A small block of a mass ***Δm*** is then added to the block hanging on the right side and the system accelerates. The linear acceleration of the blocks is ***a***. Assuming that the rope doesn't slip and there is no friction in the axle of the pulley find the mass m of the blocks and the pulley.



A . $m = \frac{\Delta m(g-a)}{2.5a}$ B. $m = \frac{\Delta m(a-g)}{a}$ C. $m = \frac{\Delta m(g-a)}{2a}$

D. $m = \frac{\Delta m(g-a)}{0.5a}$ E. $m = \frac{\Delta m(g-a)}{a}$

20. The acceleration of a mass on a spring is given by the following expression:

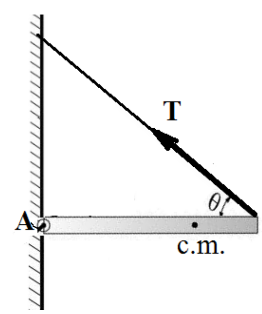
$$a = -0.98(m/s^2)\cos(3.14t)$$

What are the frequency, f, and the amplitude x_o of this motion?

A . f=0.5 rev/sec; x_o = 0.1 m B. f=2 rev/sec; x_o = 0.31 m C. f=2.5 rev/sec; x_o = 0.2 m

D. f=0.5 rev/sec; x_o = 0.31 m E. f=1.5 rev/sec; x_o = 0.3 m

21. A beam of a length L and non-uniform density λ**,** is hinged at point A and supported by a rope that makes an angle θ with the horizontal. The density of the beam increases linearly from the hinge at point A as λ **= ax**, where λ is in kg/m, the constant **a** is in kg/m^2, and **x** is the distance in meters along the beam from point A. Find the tension in the supporting rope.



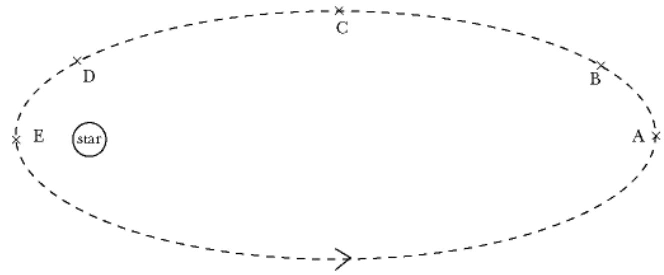
A . $\frac{agL^2}{2sin\theta}$ B. $\frac{agL^2}{3sin\theta}$ C. $\frac{agL^2}{sin\theta}$ D. $\frac{3agL^2}{2sin\theta}$ E. $\frac{agL}{2sin\theta}$

22. A solid sphere has a non-uniform density, ρ, that increases uniformly radially out from the center as, $\rho = Ar$, where A is a constant and r is the distance from the center of the sphere. The radius of the sphere is R. Compute the moment of inertia of the sphere with respect to its center of mass. Express your answer in terms of the total mass of the sphere, M.

A . $\frac{2}{3}MR^2$ B. $\frac{2}{5}MR^2$ C. $\frac{1}{9}MR^2$ D. $\frac{4}{9}MR^2$ E. $\frac{1}{3}MR^2$

For questions #23 – 24 use the following information:

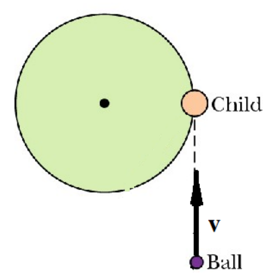
The diagram shows an elliptical orbit of a comet around a star. Assume that potential energy, U is zero when interacting objects are infinitely far apart and that the mass of the comet doesn't change in the time relevant to these questions. The letters A through E mark various positions of the comet in its orbit around the star.



23. As the comet travels around the star, the total energy of the comet-star system:
    A. Increases for ½ of the orbit, then decreases again
    B. Is always positive
    C. Equals to half of the potential energy: U/2
    D. Equals to twice the potential energy: 2U
    E. Equals to kinetic energy: U=KE

24. As the comet moves from point A to point C its
    A. linear momentum remains the same; angular momentum increases
    B. linear momentum decreases; angular momentum decreases
    C. linear momentum decreases; angular momentum increases
    D. linear momentum remains the same, angular momentum remains the same
    E. linear momentum increases; angular momentum remains the same

25. A 40 kg child is sitting on the rim of a small merry-go-round that has a mass of 120 kg and a radius of 2.0 m initially at rest. The child is playing ball with a friend who throws a 2.0 kg ball at 10 m/s tangent to the rim. What is the angular velocity of the merry-go-around right after the child catches the ball? Use a solid disk to approximate the shape of the merry-go-round.



A . 0.1 rad/s **B.** 0.2 rad/s **C.** 0.3 rad/s **D.** 0.4 rad/s E. 0.5 rad/s

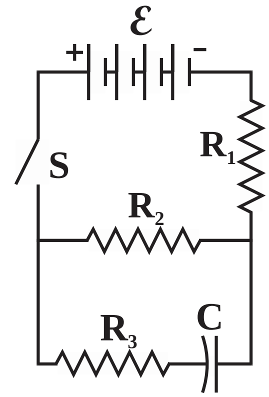
Physics C Answer Key: **<u>Orchid Test</u>**

Feb 14, 2013

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

NJ Science League Physics C March Exam 2013

Answer the following questions on the answer sheet provided. Each correct response is worth 4 points. Use the letters in parentheses for your answers. Choose the letter that best completes or answers the item. Be certain that erasures are complete. Please **PRINT** your name, school area #, and which test you are taking on the scan-tron.



In the circuit shown to the right the switch S is initially open and the capacitor is uncharged. The switch S is then quickly closed.

$\mathcal{E}$=25V, R_1=5Ω, R_2=7.5Ω, R_3=15Ω and C=5μf

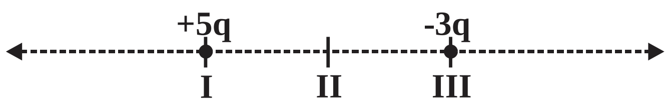
1. Immediately after the switch S is closed, the current in resistor R_1 is most nearly
   A. 1.0A B. 1.5A C. 2.0A D. 2.5A E. 3.0A

2. A long time after the switch S is closed, the current in resistor R_1 is most nearly
   A. 1.0A B. 1.5A C. 2.0A D. 2.5A E. 3.0A

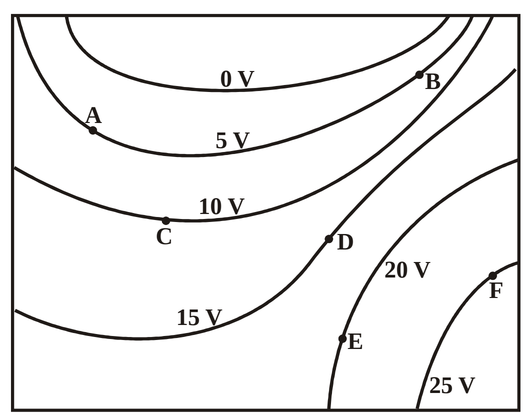
3. A long time after the switch S is closed the voltage across the capacitor C will be
   A. 3V B. 6V C. 9V D. 12V E. 15V

4. Gauss's Law provides a convenient way to calculate the electric field E outside and near each of the following isolated charged conductors except a _______.
   A. hollow sphere B. long, solid rod C. large flat plate D. solid sphere E. large loop of wire

Two charges are located on the line shown in the figure below, in which the charge at point I is +5q and the charge at point III is -3q. Point II is halfway between points I and III.



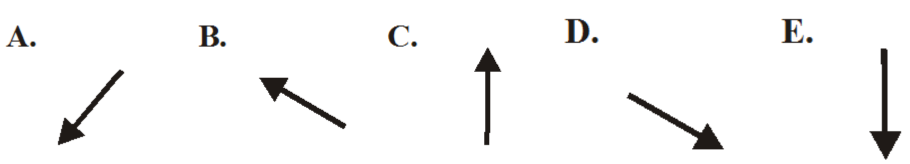
5. Other than at infinity, the electric field strength is zero at a point on the line in which of the following ranges?
   A. Left of I B. Between I and II C. Between II and III
   D. Right of III E. No such point exists



Each of the following questions refers to the equipotential diagram shown at the right of an electric field caused by an unknown distribution of static charges.

6. At which point in this electric field is the magnitude of the electric field the strongest?
   A. A B. B C. C D. D E. E

7. Which of the following vectors best describes the direction of the electric field at point E?

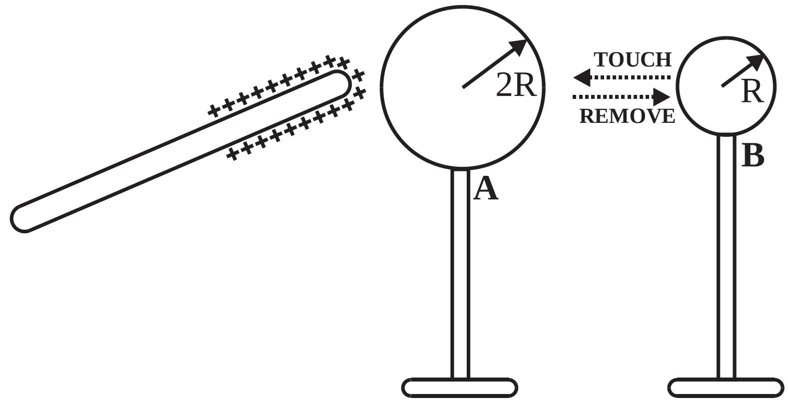


8. Gauss' Law is to be used to calculate the electric field near a charged body. In order for Gauss' Law to be used efficiently which of the following conditions should be met?
   A. The electric field should be perpendicular to the selected Gaussian surface at all points.
   B. The electric field strength should be constant at all points of the selected Gaussian surface.
   C. The electric field strength should be decreasing in strength at an exponential rate.
   D. The electric field should be zero everywhere on the Gaussian surface.
   E. Both A and B should be true.

9. The electric field near the surface of a charged conductor will always be ___________________.

A. directed away from the conducting surface at all points
B. exactly perpendicular to the surface at all points
C. exactly tangent to the conducting surface at all points
D. directed towards the conducting surface at all points
E. constant at all points

Two metal spheres that are initially uncharged are mounted on insulating stands, as shown. Sphere A has a radius 2·R and sphere B has a radius R. A positively charged glass rod is brought close to, but does not make contact with, sphere A. Sphere B is then brought close to A on the side opposite to the glass rod. Sphere B is then allowed to touch sphere A and then is removed some distance away. The glass rod is then moved far away from sphere A.



10. What are the final charges on each of the spheres?

	Sphere A	Sphere B
A.	+Q	-Q
B.	+2Q	-Q
C.	-Q	+Q
D.	-Q	+2Q
E.	+Q	-2Q

An insulating cylinder, which has a length h and a radius R, contains a total charge Q distributed uniformly throughout its interior where ρ is the charge density per unit volume. The electric field E <u>within</u> this charged, insulating cylinder is to be determined by using Gauss' Law. [Assume h>>R and ignore end effects.]

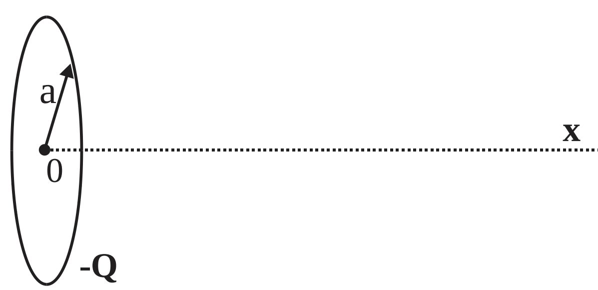
11. Which of the following expressions correctly describes the charge enclosed by an appropriately selected Gaussian surface? $q_{enclosed}$ = ___________

A. $\rho\cdot[2\cdot\pi\cdot r\cdot h]$ B. $\rho\cdot[4\cdot\pi\cdot r^2]$ C. $\rho\cdot[{}^4/_3\cdot\pi\cdot R^2]$ D. $\sigma\cdot[2\cdot\pi\cdot r\cdot h\cdot dr]$ E. $\rho\cdot[\pi\cdot r^2\cdot h]$

12. Which of the following expressions correctly describes the magnitude of the electric field within the charged, insulating cylinder? E_{within} =_________

A. ${}^4/_3\cdot k\cdot\rho\cdot\pi\cdot r$ B. ${}^4/_3\cdot k\cdot\rho\cdot r/R^2$ C. $4\cdot\pi\cdot k\cdot\rho/r^2$ D. $\rho\cdot r/(2\cdot\varepsilon_o)$ E. $Q/(4\cdot\pi\cdot r)$

Negative charge -Q is uniformly distributed over a thin ring of radius a that lies in a plane perpendicular to the x-axis with its center at the origin 0, as shown.



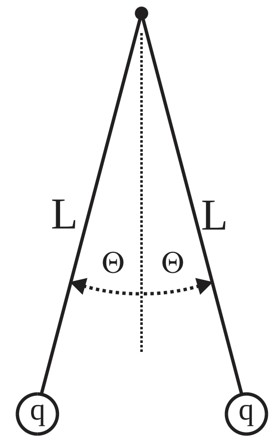
13. The potential V at points on the x-axis is represented by which of the following functions?

A. $V(x) = \frac{-kQ}{a^2+x^2}$ B. $V(x) = \frac{-kQ}{\sqrt{a^2+x^2}}$

C. $V(x) = \frac{-kQ}{x^2}$ D. $V(x) = \frac{-kQ}{a+x}$

E. $V(x) = \frac{kQ}{x}$

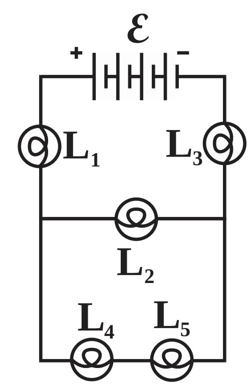
Two pith balls of equal mass are attached to the ends of two silk threads 20.0 cm long as shown to the right. A rubber rod is rubbed with wool and is then used to touch one of the pith balls transferring a charge of magnitude 0.050μC to that ball. The first pith ball then touches the second pith ball and as a result the two pith balls repel one another forming an angle of θ = 12° with the vertical as shown. [Assume that the radius of each pith ball is very small compared to the length of the string L.]



14. How many electrons were added to or removed from the first ball due to contact with the rubber rod?
    A. 4.8×10^{12} added B. 4.8×10^{12} removed C. 3.1×10^{11} added
    D. 3.1×10^{11} removed E. 1.56×10^{11} removed

15. What is the mass of each pith ball?
    A. 0.078 gm B. 0.39 gm C. 0.78 gm D. 3.12 gm E. 0.312 gm

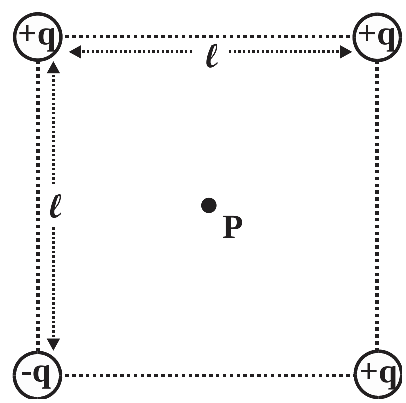
Each of the following questions refers to the diagram at the right which consists of five <u>different</u> light bulbs connected to a battery which has an EMF of $\mathcal{E}$.



16. Which of the following relationships correctly relates the voltages among these light bulbs?
    A. $V_1 = V_2$ and $V_5 = V_4$ B. $\mathcal{E} = V_3 + V_4 + V_1$ C. $V_1 = V_2 = V_3$
    D. $V_4 + V_5 = \mathcal{E}$ E. $\mathcal{E} = V_1 + V_3 + V_4 + V_5$

17. Suppose that you were to unscrew light bulb L_2. What would happen to the other light bulbs?
    A. L_1, L_3, L_4 and L_5 would get brighter, while L_2 would go out.
    B. L_4 and L_5 would get dimmer while L_3 and L_1 would get brighter.
    C. All of the light bulbs would go out.
    D. L_4 and L_5 would get brighter while L_3 and L_1 would get dimmer.
    E. All of the other light bulbs would get dimmer.

Four charges of magnitude q are arranged at the corners of a square, as shown. At the center C of the square, the potential due to one charge alone is V_o and the electric field due to one charge alone has magnitude E_o.

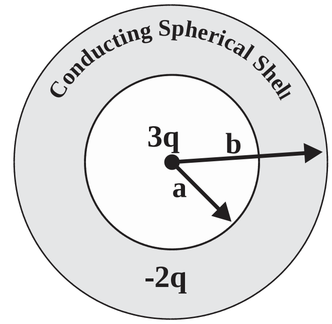


18. Which of the following correctly gives the electric potential at the center of the square due to all four charges?
    A. $V_o/2$ B. $2 \cdot V_o$ C. $4 \cdot V_o$ D. $3 \cdot V_o$ E. $5 \cdot V_o$

19. Which of the following correctly gives the magnitude of the electric field at the center of the square due to all four charges?
    A. $E_o/2$ B. $2 \cdot E_o$ C. $3 \cdot E_o$ D. $4 \cdot E_o$ E. $5 \cdot E_o$

20. How much work would be required to assemble this system of charges?
    A. 0 B. $4kq^2/l$ C. $4kq^2/\sqrt{2}l$ D. $2kq^2/\sqrt{2}l$ E. kq^2/l

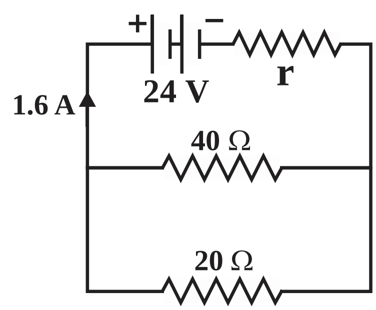
A charge of 3q is surrounded by a conducting spherical shell which contains -2q charge. The shell has an inner radius a and an outer radius b as shown.



21. What will be the charge density **σ** on the outer surface of the conducting shell?
    A. $+2q/(4\cdot\pi\cdot a^2)$ B. $+2q/(4\cdot\pi\cdot b^2)$ C. $+q/(4\cdot\pi\cdot b^2)$
    D. $-2q/(4\cdot\pi\cdot a^2)$ E. $-5q/(4\cdot\pi\cdot b^2)$

22. A wire of resistance R dissipates power P when connected to a battery with an EMF V. This wire is replaced by a second wire which has a length that is 3x the length of the first wire and which has a diameter that is half the diameter of the first wire. The power dissipated by the second wire when connected to the same battery is _______.
    A. 6P B. P/12 C. P/6 D. 4P E. P/3

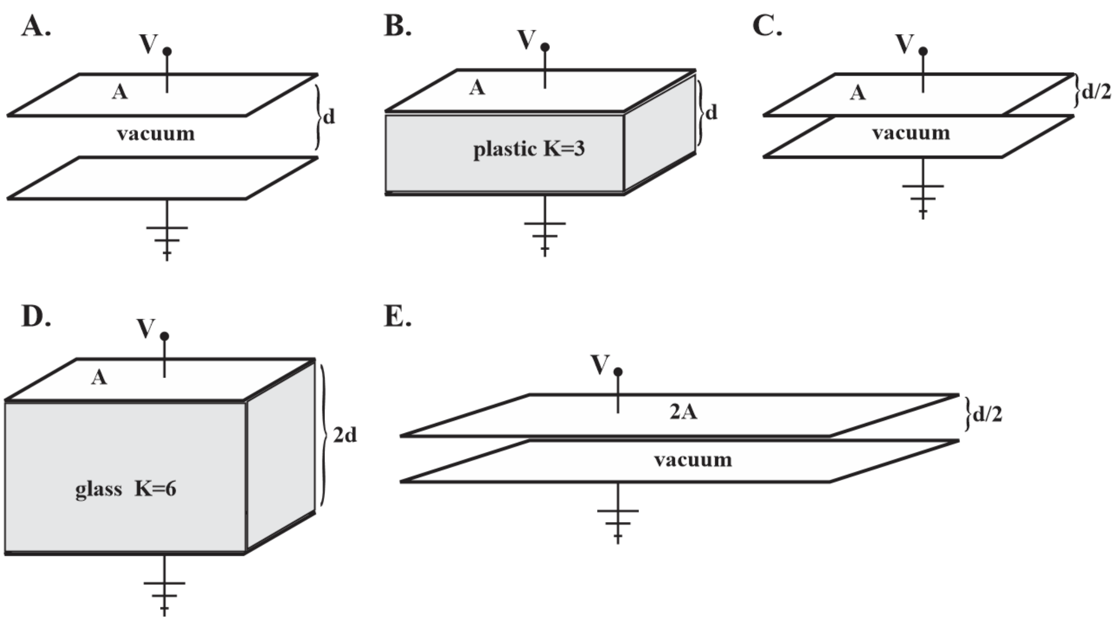
A 40-ohm resistor and a 20-ohm resistor are connected as shown to a battery which has emf of 24 volts and internal resistance r. The current in the circuit is 1.6 Amperes.



23. What is the value of the internal resistance **r** of the battery?
    A. 0.55 Ω B. 1.67 Ω C. 1.21 Ω D. 2.02 Ω E. 3.18 Ω

24. At what rate is energy being dissipated by the 20 Ω resistor?
    A. 22.8 W B. 12.4 W C. 5.7 W D. 13.4 W E. 2.25 W

25. Which of the following capacitors would store the most charge on the top plate for a given potential difference V?



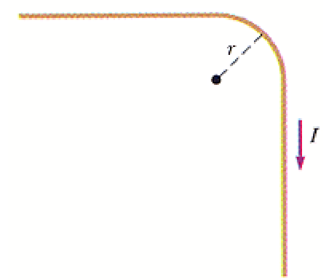
Answer Key

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

NJSL Physics C Exam April 11, 2013

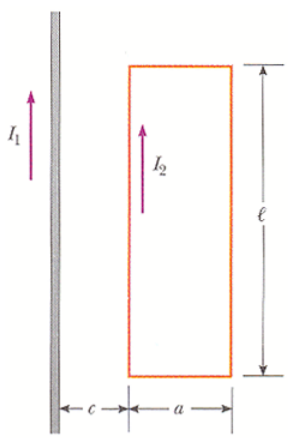
DIRECTIONS: Please PRINT your name, school, area, and which test you are taking on the scantron supplied.

ε_o=8.85x10^{-12} F/m $\mu_o = 4\cdot\pi$ x 10^{-7} N/A^2 $k_m = \mu_o/(4\cdot\pi) = 10^{-7}$ N/A^2



1. The figure shows a right-angle bend in a long straight wire carrying a current I. The bend forms a circular arc of a radius r. Determine the magnetic field at the center of the arc.

   a . $\frac{\mu_o I}{r}\frac{2\pi}{(\pi+4)}$ b. $\frac{\mu_o I(\pi+4)}{8\pi r}$ c. $\frac{\mu_o I}{2\pi r^2}$ d. $\frac{\mu_o I}{r^2}$ e. 0



__Questions #2 and 3 refer to the diagram below__

2. A long straight wire carrying a current I_1 lies in the same plane with a rectangular loop of a length ℓ and width a, carrying a current I_2. The distance between the straight wire and the closest side of the loop is c. What are the magnitude and the direction of the net force acting on the loop?

   a . 0 b. $\frac{\mu_o I_1 I_2 l}{2\pi}(\frac{1}{c}-\frac{1}{c+a})$ to the right

   c. $\frac{\mu_o I_1 I_2 l}{2\pi}(\frac{1}{c}-\frac{1}{c+a})$ to the left

   d. $\frac{\mu_o I_1 I_2 l}{2\pi c^2}$ to the right e. $\frac{\mu_o I_1 I_2 l}{2\pi a^2}$ to the left

3. Assume the initial current in the rectangular loop shown here is zero and the current in the long straight wire changes as $I = I_1\sin(\omega t)$. Here ω is the angular frequency in rad/sec. If the resistance of the loop is R, what is the induced current in the loop?

   a . $\frac{\mu_o}{2\pi R}I_1 l\omega\ln(\frac{c+a}{c})\cos(\omega t)$ b. $\frac{\mu_o}{2\pi R}I_1 la\omega\cos(\omega t)$ c. $\frac{\mu_o}{2R}I_1 la\sin(\omega t)$

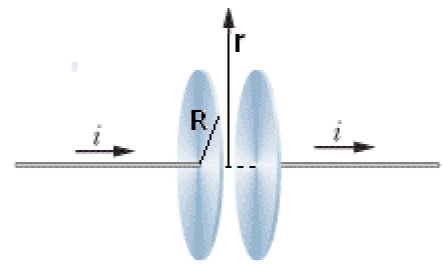
   d. $\frac{\mu_o}{2\pi}I_1 l\omega\ln(\frac{c+a}{c})\sin(\omega t)$ e. $\frac{\mu_o}{2\pi}I_1 l\omega\ln(\frac{a}{c})\cos(\omega t)$

4. Given 25 cm of a wire carrying a current of 4.0 mA, you have to make a circular coil and place it into a uniform magnetic field in such a way that the torque on the coil is maximized. Determine the magnitude of the maximum torque you achieve by making and positioning the coil in a uniform magnetic field of 50 mT.

   a . 1.25x10^{-7} N·m b. 7.35x10^{-7} N·m c. 9.95x10^{-7} N·m

   d. need to know the number of turns e. need to know the orientation of the coil

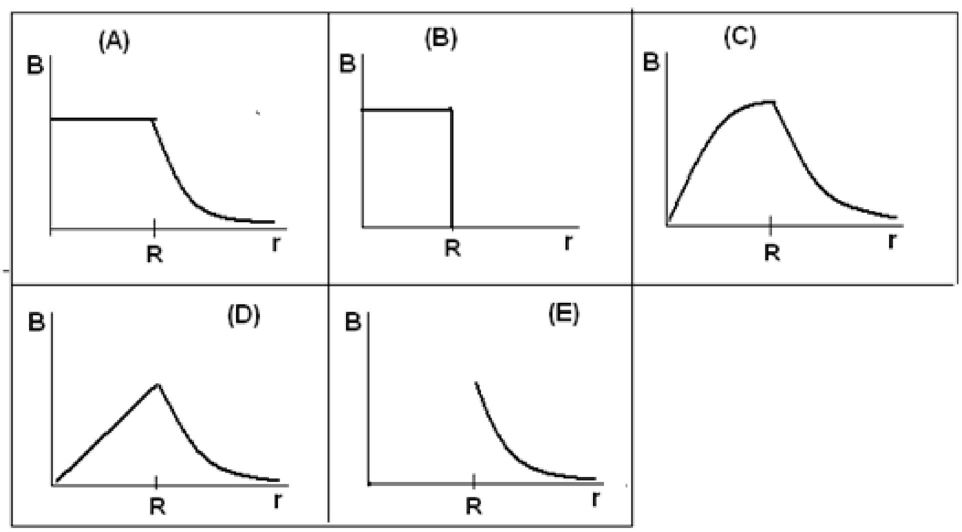
<u>For questions #5 and 6 refer to the figure</u>:



5. A parallel-plate air-filled capacitor is being charged. The plates are circular with a radius of 33.0 cm. What is the rate at which the electric field between the plates is changing at the instant the conduction current in the wires is 0.027 A?

a. 8.9×10^9 V/m·s   b. 6.5×10^9 V/m·s   c. 2.3×10^9 V/m·s   d. 3.6×10^8 V/m·s   e. 6.2×10^8 V/m·s

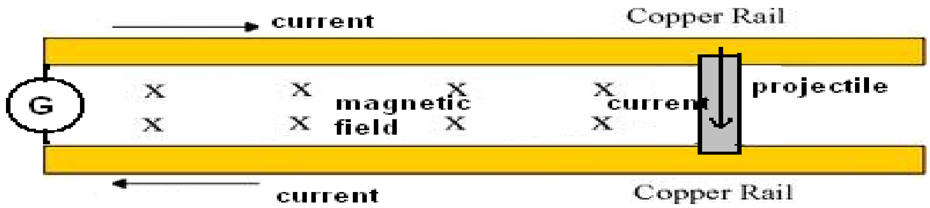
6. A parallel-plate air-filled capacitor is being charged. The plates are circular with a radius of R. Assume that the charge density on the plates is uniform at any given time. Which of the graphs below best represents magnetic field induced inside and outside of the capacitor as a function of the perpendicular distance from its axis?



a . A   b. B   c. C   d. D   e. E

7. A proton and an alpha particle (He^{++}) are accelerated from rest through a potential difference of 2000 V. What is the ratio of the speed of the proton to the speed of the alpha particle?

a . $\sqrt{2}$:1   b. 2:1   c. 4:1   d. 1:$\sqrt{2}$ e. 1:2



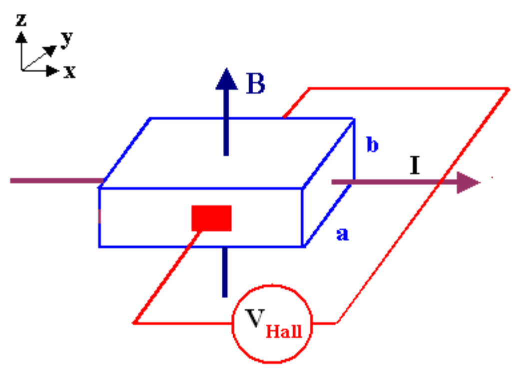
8. A rail gun consists of a metal projectile of mass m that slides without friction between two horizontal rails spaced a distance D apart. The track lies in a vertical uniform magnetic field B, as shown. Generator G produces a constant current I in the wire and the rails (even as the projectile moves). Find the velocity of the projectile as a function of time, t, assuming the projectile is stationary at t = 0.

a . $\frac{It^2}{Bm}$ b. $BIe^{-t/m}$ c. $\frac{BIDt^2}{2m}$ d. $BIDe^{-t/2m}$ e. $\frac{BIDt}{m}$

9. Magnetic monopoles do not exist. This conclusion is a direct consequence of

a . Faraday's Law b. Coulomb's Law c. Ampere's Law d. Gauss's Law e. Ohm's Law

10. A metal strip, ***a*** wide and ***b*** thick, is placed in a uniform magnetic field ***B*** directed perpendicular to the strip. A current, ***I***, is then sent through the strip such that a Hall potential difference ***V*** appears across the width of the strip. Calculate the number of charge carriers per unit volume in the metal. Here, q_e is the charge of an electron.



a . $\frac{IB}{q_eVb}$ b. $\frac{IBV}{q_eab}$ c. $\frac{IBa}{q_eV^2b}$ d. $\frac{IBb}{q_eVa}$ e. $\frac{q_eVIB}{ab}$

<u>For questions #11 and 12 use the following information:</u>

A charge ***q*** is distributed uniformly around a thin ring of a radius ***r***. The ring is rotating about an axis through its center and perpendicular to its plane, at an angular speed ***ω***.

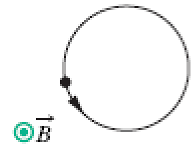
11. What is the magnitude of the magnetic moment μ, of the rotating charge?

a . $\frac{\omega r^2}{q}$ b. $q\omega r^2$ c. $\frac{q\omega}{r^2}$ d. $\frac{1}{2}q\omega r^2$ e. $\frac{q\omega}{2r^2}$

12. The rotating ring is placed into a uniform magnetic field B. The vector ***B*** makes an angle θ with the normal to the plane of the ring. The magnetic moment of the ring is μ. What is the torque applied by the magnetic field, **B**, onto the rotating ring?

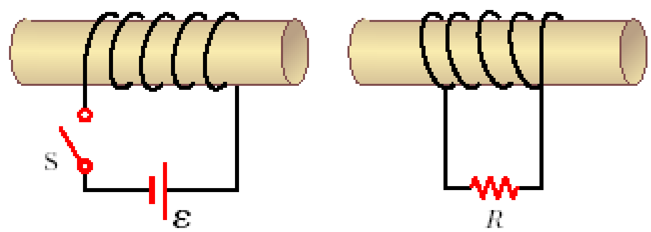
a. $\vec{\mu}\cdot\vec{B}$ b. $\vec{\mu}\times\vec{B}$ c. μB d. 0 e. $|\vec{\mu}\cdot\vec{B}|$

13. Particles rotating around the magnetic field lines can be distinguished by recording the characteristic frequency of the cyclotron radiation they emit because of this rotation. The diagram shows a particle moving in a circle in a region of uniform magnetic field of magnitude B = 4.50 mT. The particle is either a proton or an electron. Mass of a proton is $1.67x10^{-27}$ kg, mass of an electron is $9.1x10^{-31}$ kg, and the electron charge is $1.6x10^{-19}$. What is the period of the motion of the particle?



a . $8.1x10^{-9}$ s b. $9.2x10^{-6}$ s c. $4.5x10^{-9}$ s d. $6.1x10^{-7}$ s e. $1.46x10^{-5}$ s

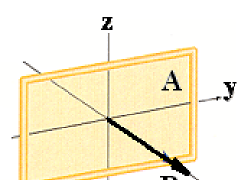
14. The circuit on the left consists of a battery and a solenoid wrapped on an iron core. The circuit on the right is simply a coil and a resistor. Choose the correct statement below.



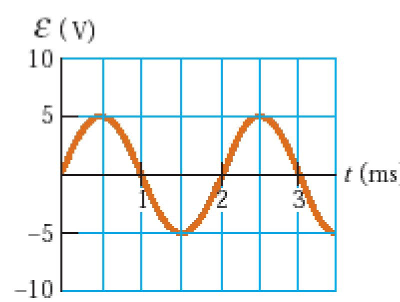
a. When the switch is first closed, the current in the resistor R, is to the left.
b. When the switch is first closed, the current in the resistor R is to the right.
c. When the switch is first closed, the current in the resistor R is zero.
d. After the switch has been closed for awhile, the current in the resistor R is to the right.
e. After the switch has been closed for awhile, the current in the resistor R is to the left.

<u>For questions #15 and 16 use the following:</u>

A rectangular coil of an area A=0.01 m^2, is positioned in z-y plane as shown. The magnetic field in the area is directed along the x-axis and equal to B=0.2 T .



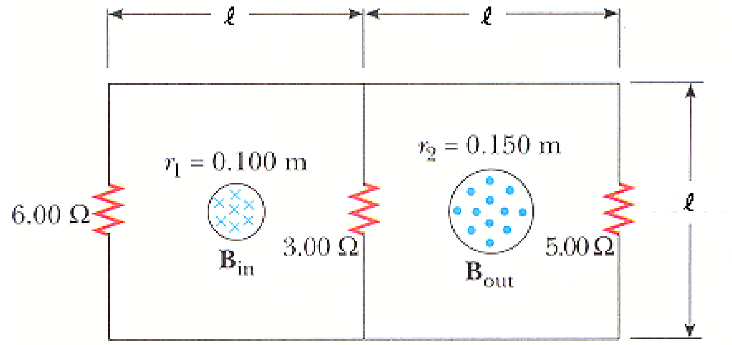
15. The coil rotates around one of its sides with an angular frequency ω=500 rad/sec. What is the maximum value of the emf induced in the coil as the coil rotates?
a. The emf can't be determined without knowing the axis of rotation
b. 0.5 V c. 0.8 V d. 1.0 V e. 1.5 V



16. Assume that the coil has a number of turns N and rotates at an angular frequency ω. The measured $\mathcal{E}(t)$ is shown here as a function of time. Then, the number of turns in the coil, N is increased by a factor of 2 and the frequency is halved. What are the new amplitude and period of $\mathcal{E}$(t)?

a . 5 mV, 4 ms b. 5 mV, 2 ms c. 2.5 mV, 2 ms d. 10 mV, 2 ms
e. 10 mV, 4 ms

17. Two infinitely long solenoids (seen in cross section) pass through a circuit as shown. The magnitude of $\vec{\mathbf{B}}$ inside each is the same and is increasing at the rate of d$\vec{\mathbf{B}}$/dt = 90 mT/sec. What is the direction of the current in the 3 Ω resistor?

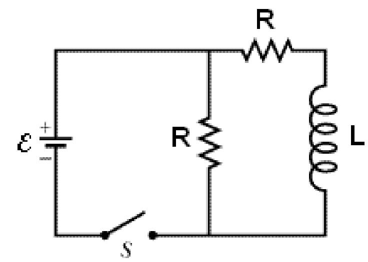


a . up b. down c. 0

d. impossible to determine

<u>For questions #18 and 19 use the following circuit:</u>

The voltage on the battery is Ɛ , the resistance of both resistors is R as shown, and the inductance of the coil is L.



18. Immediately after the switch is closed, the current through the battery is

a . 0 b. $\frac{\varepsilon}{L}$ c. $\frac{\varepsilon}{2R}$ d. $\frac{\varepsilon}{R}$ e. $\frac{2\varepsilon}{R}$

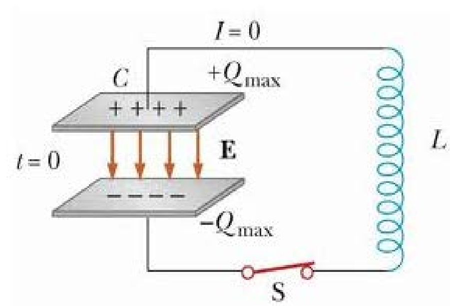
A very long time after the switch is closed the current through the battery is

a . 0 b. $\frac{\varepsilon}{L}$ c. $\frac{\varepsilon}{2R}$ d. $\frac{\varepsilon}{R}$ e. $\frac{2\varepsilon}{R}$

19. A 12.0 V battery is connected into a series circuit containing a 10.0 Ω resistor, a 2.00 mH inductor, and a switch. The switch is open at t<0 . The switch is closed at t=0. How long will it take the current to reach 50.0% of its final value?

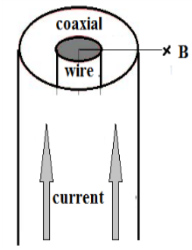
a. 0.2 ms b. 0.67 ms c. 0.14 ms d. 0.31 ms e. 0.5 ms

21. At some instant in an oscillating LC circuit, 67.0% of the total energy is stored in the magnetic field of the inductor. What multiple of the maximum charge Q_{max} is on the capacitor?



a . 0.574 b. 0.819 c. 0.437 d. 0.67 e. 0.731

22. A long vertical wire carries an unknown current. Coaxial with the wire is a long, thin, cylindrical conducting surface that carries a current of 30 mA upward. The cylindrical surface has a radius of 3.0 mm. The magnitude of the magnetic field at a point 3.5 mm from a center of the wire is 1.0 μT and the direction of the field is shown in the diagram. What are the value and the direction of the current in the wire?



a . 10 mA, upward b. 10 mA, downward c. 12.5 mA, upward d. 12.5 mA, downward e. 0

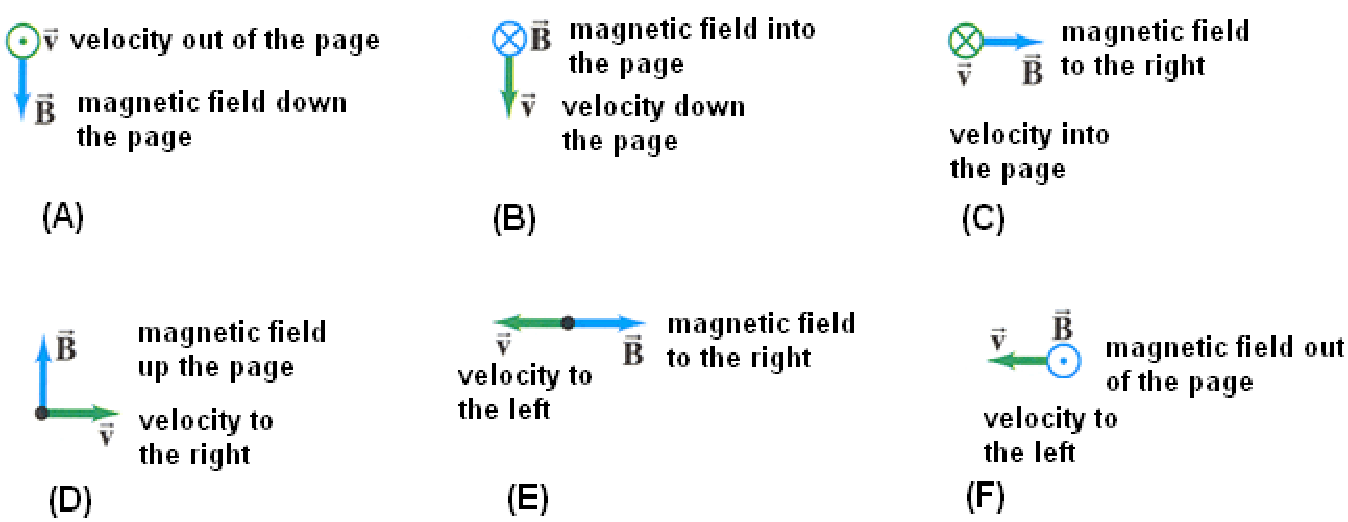
23. If the magnetic field $\vec{B}$ is constant and uniform over the area bounded by a square with edge length $\boldsymbol{a}$, the net current through the square is:

a . $\frac{B}{\mu_o}$ b. $\frac{Ba^2}{\mu_o}$ c. $\frac{Ba}{2\mu_o}$ d. $\frac{4Ba}{\mu_o}$ e. 0

24. Two parallel wires, 4 cm apart, carry currents of 2 A and 4 A respectively, in the same direction. The force per unit length in N/m of one wire on the other is:

a . $1x10^{-3}$ N/m , attractive b. $4x10^{-5}$, attractive
c. $1X10^{-3}$, repulsive d. $4x10^{-5}$, repulsive e. 0

25. Each of the vector diagrams below show the direction of the velocity of an electron and the direction the magnetic field in the region.



Which of the diagrams shows a situation that results in a magnetic force on the electron directed to your left (when you are facing this page)?

a . D and E b. F only c. C and F d. D only e. A and B

KEY

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