Physics C Science League Test **ORCHID TEST**

January 15, 2015

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

**Use g = 10 m/s$^2$**

1. A Ferris wheel with a radius of 8.0 m makes 1 revolution every 10 s. When at the top, essentially a diameter above the ground, a ball is released. How far from the point on the ground directly under the release point does the ball land?

    a. 1.0 m  b. 16 m  c. 8.0 m  d. 9.0 m  e. 0

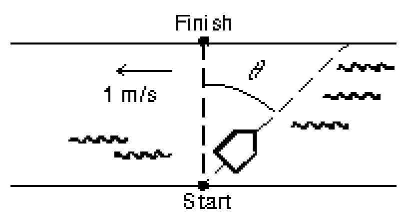
2. A ferry boat is sailing at 12 km 30° W of N with respect to a river that is flowing at 6.0 km/h E. As observed from the shore, the ferry boat is sailing:

    a. 30° E of N  b. due N  c. 30° W of N  d. 45° E of N  e. 45° W of N

3. At time $t = 0$ a car has a velocity of 16 m/s. It slows down with an acceleration given by $-0.50t$, in m/s$^2$ for $t$ in seconds. By the time it stops it has traveled:

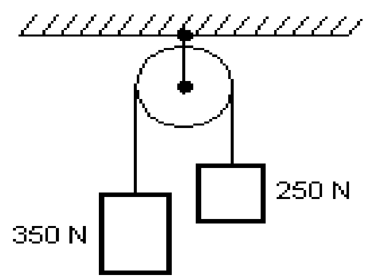
    a. 15 m  b. 31 m  c. 62 m  d. 85 m  e. 100 m

4. A girl wishes to swim across a river to a point directly opposite as shown below. She can swim at 2 m/s in still water and the river is flowing at 1 m/s. At what angle θ with respect to the line joining the starting and finishing points should she swim?



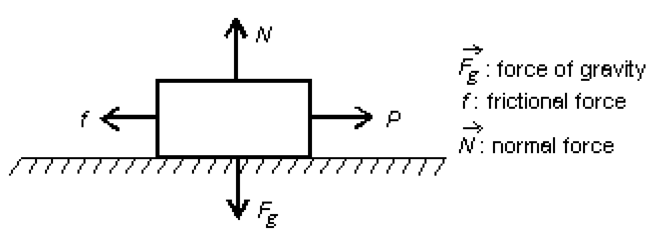

    a. 30°  b. 45°  c. 60°  d. 63°  e. 90°

5. Two blocks weighing 250 N and 350 N respectively, are connected by a string that passes over a mass less pulley as shown below. The tension in the string is:



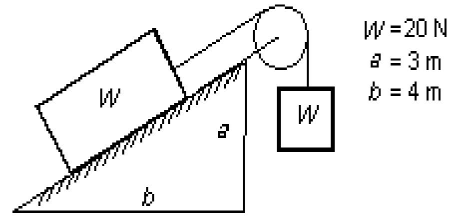

    a. 210 N  b. 410 N  c. 4900 N  d. 290 N  e. 500 N

6. A boy pulls a wooden box along a rough horizontal floor at constant speed by means of a force *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?



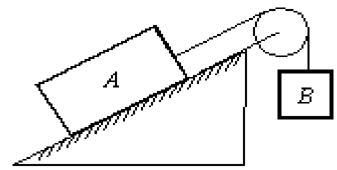

    a. P = f and N = $F_g$
    b. P = f and N > $F_g$
    c. P > f and N < $F_g$
    d. P > f and N = $F_g$
    e. None of the above

7. The system shown to the right remains at rest. The force of friction on the block on the inclined plane is:




a. 4 N  b. 8 N  c. 12 N
d. 16 N  e. 20 N

8. As shown to the right, 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. 2.4 kg  b. 3.5 kg  c. 5.9 kg  d. 9.0 kg  e. 10.5 kg

9. The potential energy of a particle moving along the $x$ axis is given by

$$U(x) = (8.0\text{J/m}^2)x^2 + (2.0\text{J/m}^4)x^4.$$

If the total mechanical energy is 9.0 J, the limits of motion are:

a. -0.96 m; +.96 m  b. -2.2 m; +2.2 m  c. -1.6 m; +1.6 m
d. -0.96 m; +2.2 m  e. -0.96 m; +1.6 m

10. The potential energy of a 0.20-kg particle moving along the $x$ axis is given by

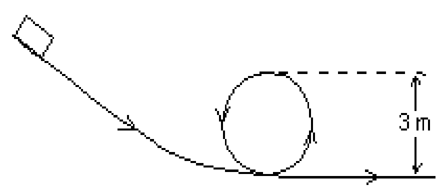
$$U(x) = (8.0\text{J/m}^2)x^2 + (2.0\text{J/m}^4)x^4.$$

When the particle is at $x = 1.0$ m, it is traveling in the positive $x$ direction with a speed of 5.0 m/s. It next stops momentarily to turn around at x=___?___

a. 0  b. -1.1 m  c. +1.1 m  d. -2.3 m  e. +2.3 m

11. A car moves horizontally with a constant acceleration of 3 m/s$^2$. A ball is suspended by a string from the ceiling of the car; the ball does not swing, being at rest with respect to the car. What angle does the string make with the vertical?
a. 17°  b. 35°  c. 52°  d. 73°
e. Cannot be found without knowing the length of the string

12. A small object shown slides along the frictionless loop-the-loop with a diameter of 3 m. What minimum speed must it have in order to stay in the loop without falling?
a. 1.9 m/s  b. 3.9 m/s  c. 5.4 m/s
b. d. 15 m/s  e. 29 m/s



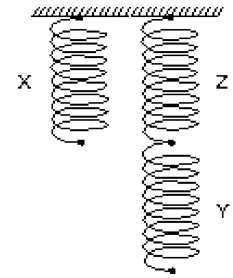
13. A man pushes an 80-N crate a distance of 5.0 m upward along a frictionless slope that makes an angle of 30° with the horizontal. His force is parallel to the slope. If the speed of the crate decreases at a rate of 1.5 m/s$^2$, then the work done by the man is:

a. 400 J    b. -400 J    c. 140 J    d. -140 J    e. (348 J) î + (200 J) ĵ

14. An ideal spring is hung vertically from the ceiling. When a 2.0 kg mass is attached to the spring, the spring extends 6.0 cm from the spring's relaxed position. 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 external force, the work done by the spring is:

a. -3.6 J    b. -3.3 J    c. -3.4 x 10$^{-5}$ J    d. 3.3 J    e. 3.6 J

15. Three identical springs (X,Y,Z) are arranged as shown on the right. When a 4.0-kg mass is hung on X, the mass descends 3.0 cm. When a 6.0-kg mass is hung on Y, the mass descends:




a. 2.0 cm    b. 4.0 cm    c. 4.5 cm    d. 6.0 cm    e. 9.0 cm

16. Identical guns fire identical bullets horizontally at the same speed from the same height above level planes, one on the Earth and one on the Moon. Which statement(s) is/are true?

I. The horizontal distance traveled by the bullet is greater for the Moon.
II. The flight time is less for the bullet on the Earth.
III. The velocities of the bullets at impact are the same.

a. III only    b. I & II only    c. I & III only    d. II & III only    e. I, II, III

17. A particle moves along the $x$ axis under the influence of a stationary object. The net force on the particle, which is conservative, is given by $F = (8\text{N/m}^3)x^3$. If the potential energy is taken to be zero for $x = 0$ then the potential energy is given by:

a. (2 J/m$^4$) x$^4$    b. (-2 J/m$^4$) x$^4$    c. (24 J/m$^2$) x$^2$    d. (-24 J/m$^2$) x$^2$    e. 5J - (2 J/m$^4$) x$^4$

18. A projectile of mass 0.500 kg is fired with an initial speed of 10.0 m/s at an angle of 60.0° above the horizontal. The potential energy of the projectile-Earth system when the projectile is at its highest point (relative to the potential energy when the projectile is at ground level) is:

a. 25.0 J    b. 18.8 J    c. 12.5 J    d. 6.25 J    e. 2.0 J

19. Ball B, moving in the positive direction of an x-axis at speed v, collies with stationary ball A at the origin. A and B have different masses. After the collision, B moves in the negative direction of the y-axis at a speed v/3. What direction does A move?

a. There is no way to tell    b. +10°    c. -10°    d. 27°    e. 18°

20. A certain radioactive (parent) nucleus transforms to a different (daughter) nucleus by emitting an electron and an anti-neutrino. The parent was at rest at the origin of an xy coordinate system. The electron moves away from the origin with linear momentum ($-4.2 \times 10^{-22}$ kg m/s) $\hat{\imath}$. The neutrino moves away from the origin with a linear momentum ($-7.1 \times 10^{-23}$ kg m/s) $\hat{\jmath}$. What is the linear momentum of the daughter nucleus?

a. $1.4 \times 10^{-22}$ kg m/s; +28°  b. $1.2 \times 10^{-22}$ kg m/s; +14°  c. $6.4 \times 10^{-22}$ kg m/s; +5.2°

d. $5.8 \times 10^{-22}$ kg m/s; +32°  e. $4.3 \times 10^{-22}$ kg m/s; +9.6°

21. A block of mass *m* is initially moving to the right on a horizontal frictionless surface at a speed *v*. It then compresses a spring of spring constant *k*. At the instant when the kinetic energy of the block is equal to the potential energy of the spring, the spring is compressed a distance of:

a. $v\sqrt{m/2k}$  b. ½ $mv^2$  c. ¼ $mv^2$  d. $mv^2/4k$  e. $\left(1/4\right)\sqrt{mv/k}$

22. 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, 45° 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.

23. 2.0-kg block is attached to one end of a spring with a spring constant of 100 N/m and a 4.0-kg block is attached to the other end. The blocks are placed on a horizontal frictionless surface and set into motion. At one instant the 2.0-kg block is observed to be traveling to the right with a speed of 0.50 m/s and the 4.0-kg block is observed to be traveling to the left with a speed of 0.30 m/s. Since the only forces on the blocks are the force of gravity, the normal force of the surface, and the force of the spring, we conclude that:

a. The spring is compressed at the time of the observation.
b. The spring is not compressed at the time of the observation.
c. The motion was started with the masses at rest.
d. The motion was started with at least one of the masses moving.
e. The motion was started by compressing the spring.

24. Blocks A and B are moving toward each other. A has a mass of 2.0 kg and a velocity of 50 m/s, while B has a mass of 4.0 kg and a velocity of –25 m/s. They suffer a completely inelastic collision. The kinetic energy lost during the collision is:

a. 0  b. 1250 J  c. 3750 J  d. 5000 J  e. 5600 J

25. An airplane makes a gradual 90° 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 $m/s^2$

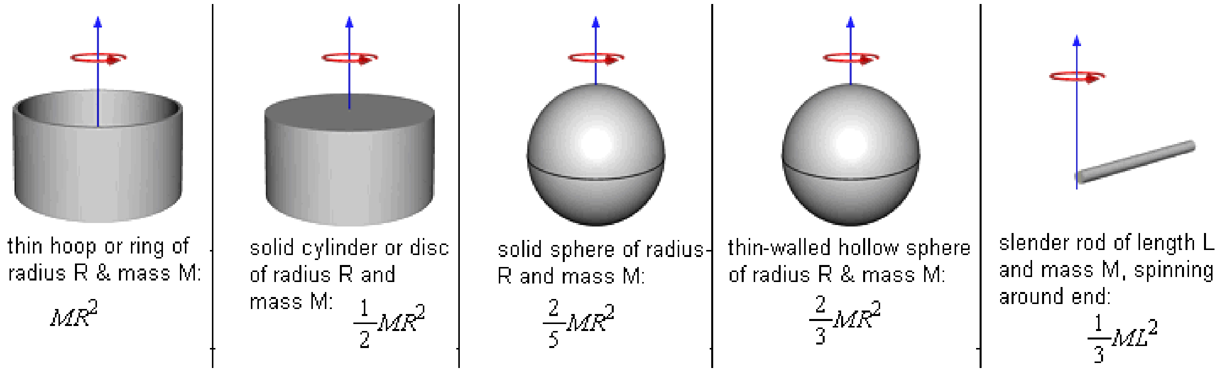
# Physics C Answer Key: **<u>Orchid Test</u>**
# Jan 15, 2015

| | | | | |
|---|---|---|---|---|
| 1-D | 6-A | 11-A | 16-B | 21-A |
| 2-B(all full credit) | 7-B | 12-B | 17-B | 22-B |
| 3-D | 8-A | 13-C | 18-B | 23-D |
| 4-A | 9-A | 14-A | 19-E | 24-C |
| 5-D | 10-C | 15-E | 20-E | 25-D |

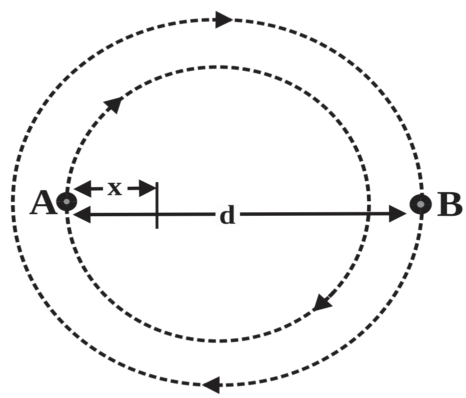
Physics C Science League Test **<u>ORCHID TEST</u>**

February 12, 2015

**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. Sketches are not to scale. Assume g = 9.8m/s$^2$ and the following moments of inertia:**




**Questions 1, 2, 3 refer to the diagram at the right which shows two stars orbiting one another in stable circular orbits about a common center of mass. Star A has a mass 3M while star B has a mass M. The distance between the two stars is d and the distance between star A and the point about which these two stars are orbiting is x.**




1. What is the distance x between star A and the center of rotation of this star system?
   A. d/4 B. d/5 C. d/3 D. d/2 E. d/7

2. What is the total moment of inertia of this system of two stars about the center of rotation?
   A. 5Md$^2$ B. 4Md$^2$ C. $^4/_5$Md$^2$ D. $^3/_4$Md$^2$ E. $^1/_2$Md$^2$

3. What is the tangential velocity $v_A$ of star A?
   A. $\sqrt{\frac{3GM}{4d}}$ B. $\sqrt{\frac{GM}{3d}}$ C. $\sqrt{\frac{4GM}{3d}}$ D. $\sqrt{\frac{2GM}{3d}}$ E. $\sqrt{\frac{GM}{4d}}$

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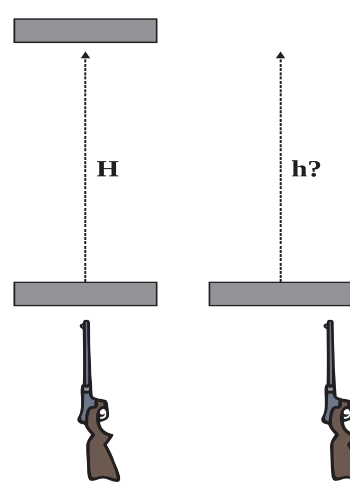
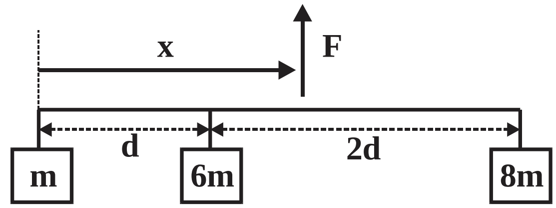
4. A vertically mounted rifle is used to fire a bullet into the center of a wood block and as a result the center of mass of the bullet-block system rises to a height H. The rifle is then displaced slightly to the right so that the bullet strikes the block near the end rather than the center after which the center of mass of the block rises to a height h. In each case the bullet remains lodged in the block after impact. Which of the following statements is **<u>correct</u>**?



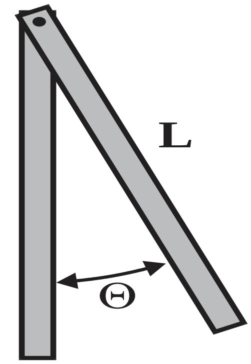

   A. The new height h will be less than the original height H since some of the initial kinetic energy of the bullet now takes the form of rotational kinetic energy.
   B. The new height h will be less than the original height H because some of the linear momentum of the bullet will be converted to angular momentum.
   C. The new height h will be equal to the original height H because kinetic energy is conserved equally in both collisions.
   D. The new height h will be greater than the original height H since the bullet will penetrate the wood less in the second case resulting in greater linear kinetic energy after the collision.
   E. The new height h will be equal to the original height H because linear momentum is conserved equally in both cases.

5. Three masses are suspended from a horizontal rod of negligible mass as shown to the right. How far **x** from the left end of this bar could a single upward force **F** be applied in order to produce perfect equilibrium?

A. 1.3d B. 1.5d C. 1.8d D. 2.0d E. 2.25d




**A uniform rod with a mass** M **and a length** L **is suspended about a pivot point through one end as shown to the right. The bottom end of the rod is displaced slightly to the right until the angle between the rod and the vertical is** Θ **and is then released allowing the rod to oscillate about the pivot point with a period** T**.**



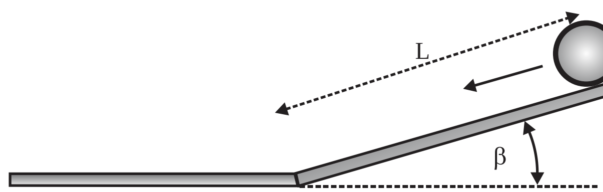

6. How could this system be changed so as to increase the angular frequency of the rod's oscillations?

A. Increase the angle Θ between the rod and the vertical.
B. Increase the mass of the rod while keeping the length constant.
C. Decrease the length of the rod while keeping the mass constant.
D. Decrease the mass of the rod while making the rod longer.
E. Increase both the mass and the length of the rod.

7. How much work will be done in displacing this rod to the angle Θ?

A. $M \cdot g \cdot L$ B. $M \cdot g \cdot L \cdot \cos(\Theta)$ C. $M \cdot g \cdot L \cdot \cos\Theta/2$
D. $M \cdot g \cdot L \cdot (1-\cos\Theta)/2$ E. $2M \cdot g \cdot L \cdot (1-\cos^2\Theta)$

**A solid uniform sphere which has a mass m is released from rest at the top of an inclined plane which has a length L, meets the horizontal at an angle β and has a coefficient of static friction of $\mu_s$ between the ball and the incline. The ball rolls to the bottom of the incline without slipping.**




8. What will be the magnitude of the frictional force between the sphere and the surface of the incline as the sphere rolls to the bottom of the incline without slipping?

A. $mg\mu \cdot \sin\beta$ B. $^2/_7 \cdot mg \cdot \sin\beta$ C. $^2/_5 \cdot mg\mu \cdot \cos\beta$ D. $^2/_5 \cdot mg\mu \cdot \sin\beta$ E. $^3/_5 \cdot mg \cdot \sin\beta$

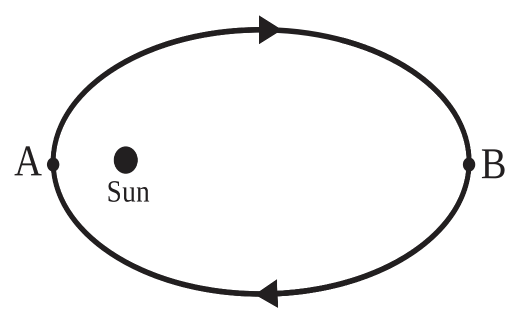
9. What will be the linear velocity of the sphere just as it reaches the bottom of the incline?

A. $\sqrt{\frac{4gL\sin(\beta)}{7}}$ B. $\sqrt{\frac{4gL\cos(\beta)}{7}}$ C. $\sqrt{\frac{10gL\sin(\beta)}{7}}$ D. $\sqrt{\frac{5gL\sin(\beta)}{4}}$ E. $\sqrt{\frac{4gL\sin(\beta)}{5}}$

10. A ball is dropped from a height of 5.0 meters onto a hard surface so that the collision at the surface may be assumed completely elastic. Under such conditions the motion of the ball is _______________.

A. periodic with a period of about 1.0 s but not simple harmonic
B. periodic with a period of about 2.0 s but not simple harmonic
C. simple harmonic with a period of about 1.0 s
D. simple harmonic with a period of about 2.0 s
E. simple harmonic with an amplitude of 5.0 m

11. A satellite travels around the Sun in an elliptical orbit as shown to the right. As the satellite travels from point A to point B, which of the following is true about its speed, potential energy and angular momentum?




| | Speed | Potential Energy | Angular Momentum |
|---|---|---|---|
| A. | Increases | Remains Constant | Remains Constant |
| B. | Increases | Decreases | Increases |
| C. | Remains Constant | Increases | Decreases |
| D. | Decreases | Increases | Remains Constant |
| E. | Decreases | Decreases | Increases |

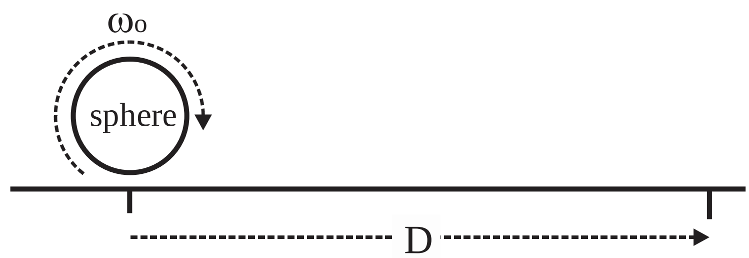
**Consider a turntable, which has a moment of inertia $I = 50\ kg\cdot m^2$, that is initially rotating with an angular velocity of -15 rad/s. An external torque is applied to the turntable so as to generate a constant angular acceleration of 5.0 rad/s$^2$ until the angular velocity reaches a final value of 30 rad/sec.**

12. What is the total angular displacement of the turntable during the time that this external torque is being applied?
    A. 45 rad  B. 62 rad  C. 68 rad  D. 93 rad  E. 112 rad

13. What is the magnitude of the applied torque?
    A. 120 N·m  B. 180 N·m  C. 250 N·m  D. 280 N·m  E. 310 N·m

14. How much net work was done on the turntable by the applied torque?
    A. 14,000 J  B. 17,000 J  C. 22,000 J  D. 28,000 J  E. 35,000 J

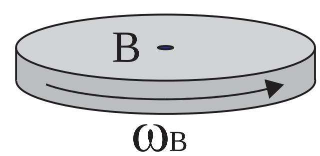
**A solid sphere, which has a mass M and a radius R, is given an initial angular velocity $\omega_o$ and is then gently released onto a horizontal surface that has a coefficient of kinetic friction $\mu$ as shown to the right. Initially, the sphere slips along the surface until it has moved a distance D after which the sphere rolls without slipping.**



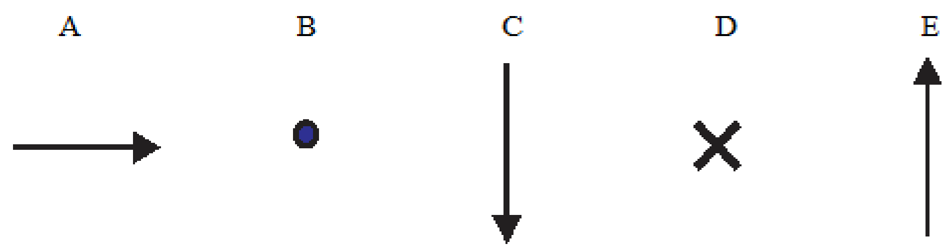

15. What will be the resulting angular acceleration of the sphere, while it is slipping along the horizontal surface?
    A. $-{}^2/_5\, g\cdot\mu/R$  B. $-{}^5/_2\cdot g\cdot\mu$  C. $5\cdot g\cdot\mu/2R$  D. $-2\cdot g\cdot\mu$  E. $5\cdot g\cdot\mu$

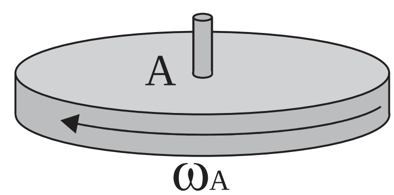
16. How long will it take before the sphere finally starts to roll without slipping?
    A. $2\cdot\omega_o\cdot R/7g\mu$  B. $2\cdot\omega_o\cdot R/5g\mu$  C. $5\cdot\omega_o\cdot R/2g\mu$  D. $2\cdot\omega_o/5g\mu$  E. $\omega_o\cdot R/2g\mu$

**A uniform disk B, which has a mass m and radius R, is rotating with an initial angular velocity $\omega_B$ as shown to the right.**




17. Which of the following vectors correctly points in the direction of the initial angular momentum of disk B?




**Disk B is then gently placed onto disk A, which has a mass 2m and radius 2R, which is rotating with an initial angular $\omega_A$ as shown where the initial magnitude of the angular velocity of disk A is one third the initial angular velocity of disk B: $\omega_A = \omega_B/3$. The frictional force between the two disks acts until finally the two disks rotate together with a final angular velocity $\omega_f$.**

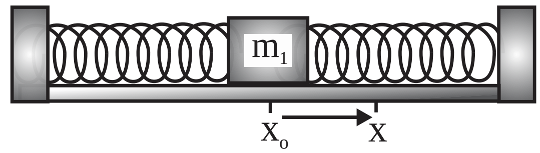
18. What is the ratio of the moment of inertia of disk A to disk B?
    A. 2:1  B. 3:1  C. 4:1  D. 6:1  E. 8:1

19. What will be the final angular velocity $\omega_f$ of this system?
    A. ${}^3/_8\,\omega_A$  B. ${}^5/_8\,\omega_A$  C. $-{}^3/_8\,\omega_A$  D. $-{}^5/_9\,\omega_A$  E. ${}^4/_8\,\omega_A$

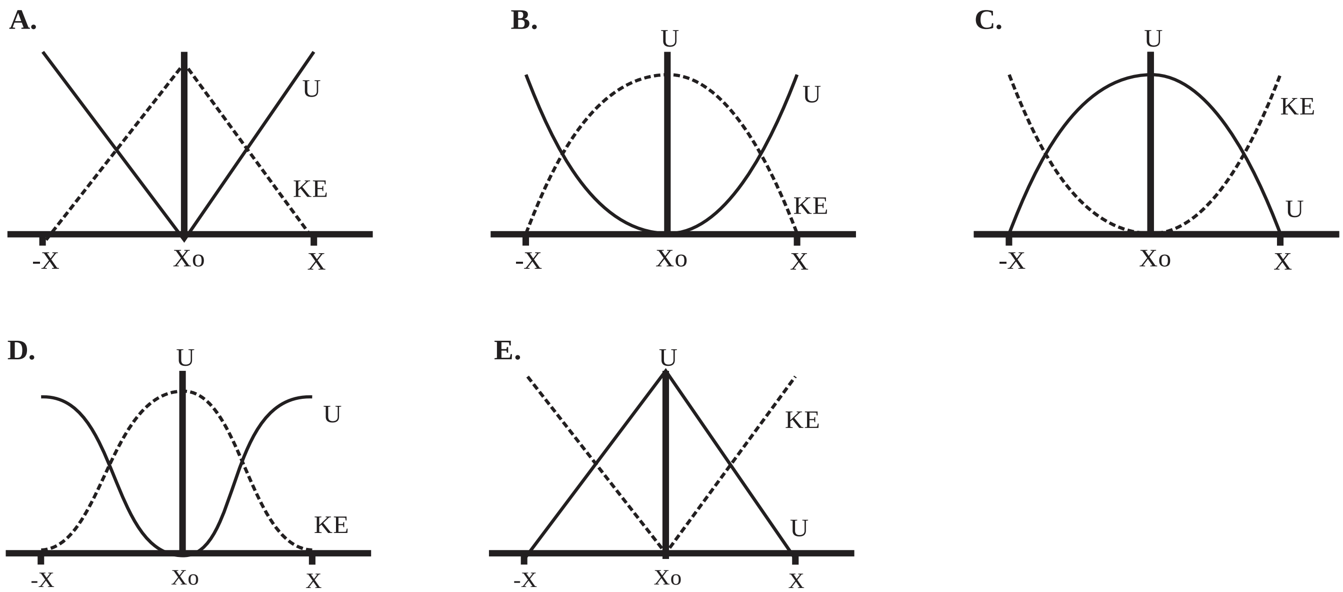
20. A satellite, which has a mass of 320kg, is orbiting the planet Mars [$m_{Mars}$=6.42 x $10^{23}$ kg, $R_{Mars}$=3.39 x $10^6$m, G = 6.67 x $10^{-11}$N•m$^2$/kg$^2$] at an altitude of 1.61 x $10^6$m. Engines aboard the satellite are ignited so as to accelerate this satellite such that when the satellite is far away from Mars its velocity will be 3300 m/s. How much mechanical energy must be added to this orbiting satellite by the engines?

A. 1.37 x $10^9$ J  B. 2.74 x $10^9$ J  C. 3.80 x $10^8$ J  D. 5.22 x $10^9$ J  E. 3.11 x $10^9$ J

**A mass $m_1$ = 2.0kg is suspended between two springs, each with a spring constant k = 400N/m. The mass is displaced a distance X = 15cm from the equilibrium point $X_o$ and is then released.**




21. Which of the following graphs best describes the kinetic and potential energies of this system as the mass oscillates back and forth between the two springs?




22. What is the angular frequency of this oscillator?

A. 5/s  B. 20/s  C. 10/s  D. 15/s  E. 30/s

23. Which of the following expressions best describes the linear velocity of this mass as a function of time?

A. –3.0•sin(20t)  B. –0.15•cos(15t)  C. –0.45•sin(30t)  D. –3.0•cos(30t)  E. 0.45•sin(5t)

**For the balance of this problem assume that the initial total energy of this system is 90.0 Joules and that the period of oscillation is T = 0.314 s. Suppose that there is a frictional force acting on this mass as it oscillates and that after 10 complete cycles the maximum amplitude of the oscillations has decreased to $X_o$/2.**

24. What is the time constant for this damped oscillator?

A. 2.26 s  B. 1.45 s  C. 7.22 s  D. 3.14 s  E. 6.28 s

25. How much work will be done by the frictional force on this system during the first 20 cycles?

A. 42.2 J  B. 55.0 J  C. 62.5 J  D. 67.5 J  E. 84.4 J

# Physics C Answer Key: **Orchid Test**

Feb 12, 2015

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

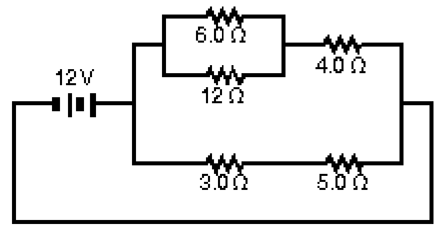
Physics C Science League Test **Orchid**

March 12, 2015 (Correction)

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

$k = 9.0 \times 10^{9}\ Nm^2/C^2$ $\epsilon_o = 8.854 \times 10^{-12}$ F/m

1. The current in the 5.0 Ω resistor in the circuit shown to the right is:

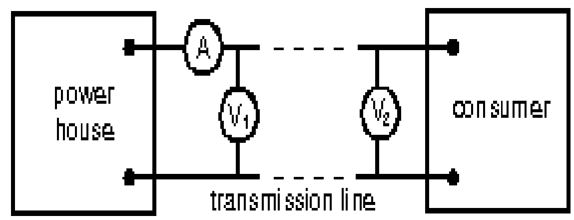



a. 0.42 A b. 0.67 A
c. 1.5 A d. 2.4 A e. 3.0 A

2. Resistor 1 has twice the resistance of resistor 2. The two are connected in parallel and a potential difference is maintained across the combination. The rate of thermal energy dissipation in 1 is:

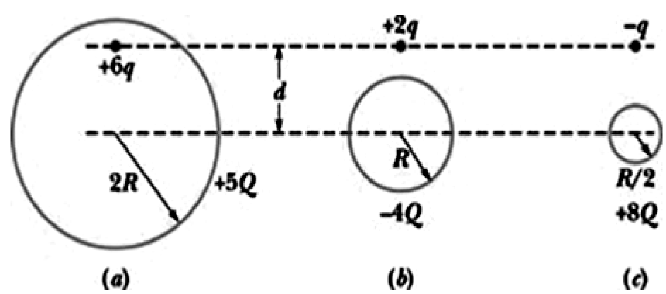
a. the same as that in 2
b. twice that in 2
c. half that in 2
d. four times that in 2
e. one fourth that in 2

3. In the right 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:



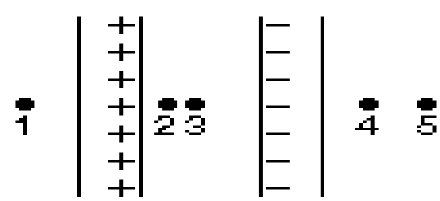

a. 1 kW b. 2 kW
c. 58 kW d. 59 kW e. 60 kW

4. The right figure shows three situations involving a charged particle and a uniformly charged spherical shell. The charges are given, and the radii of the shells are indicated. Rank the situations according to the magnitude of the force on the particle due to the presence of the shell. Largest to smallest.



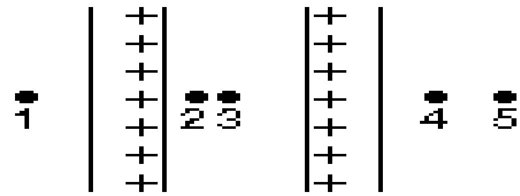

a. a > b > c b. a = b = c
c. b = c > a d. c > b > a
e. b > a > c

5. Two infinitely large parallel plates made of insulated material carry charge of equal magnitude, <u>one positive and the other negative</u>, 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, **<u>least to greatest.</u>**




a. 2 & 3 tie, then 1 & 4 tie, then 5
b. 1, 4, & 5 tie, then 2 & 3 tie
c. 2 & 3 tie, then 1, 4, & 5 tie
d. 1, 2, 3, 4, 5
e. 5, 4, 3, 2, 1

6. Two large parallel plates carry <u>positive charge of equal magnitude</u> 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.

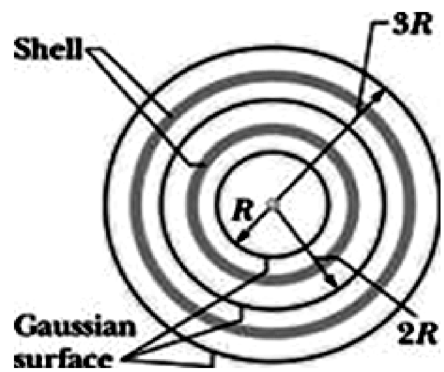



a. 1, 4, & 5 tie, then 2 & 3 tie
b. 2 & 3 tie, then 1 & 4 tie, then 5
c. 2 & 3 tie, then 1, 4, & 5 tie
d. 1, 2, 3, 4, 5
e. 5, 4, 3, 2, 1

7. 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 outside the shell, a distance $r$ from the center, is:

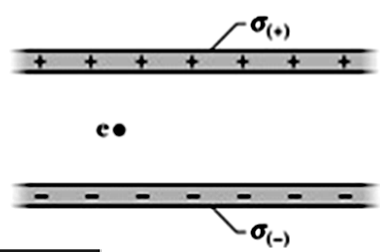
a. $\frac{Q}{4\pi\epsilon_O}\frac{1}{R_1^2}$ b. $\frac{q}{4\pi\epsilon_O}\frac{1}{R_1^2-r^2}$ c. $\frac{q}{4\pi\epsilon_O}\frac{1}{r^2}$ d. $\frac{q+Q}{4\pi\epsilon_O}\frac{1}{r^2}$ e. $\frac{q+Q}{4\pi\epsilon_O}\frac{1}{R_1^2-r^2}$

8. The figure shows, in cross section, a central metal ball, two spherical metal shells, and three spherical Gaussian surfaces of radii $R$, $2R$, and $3R$, all with the same center. The uniform charges on the three objects are: ball, $Q$; smaller shell, $3Q$; larger shell, $5Q$. Rank the Gaussian surfaces according to the magnitude of the electric field at any point on the surface, greatest first.




a. E(3R) > E(2R) > E(R)
b. E(3R) = E(2R) = E(R)
c. E(3R) < E(2R) < E(R)
d. E(3R) > E(2R) = E (R)
e. E(3R) < E(2R) = E(R)

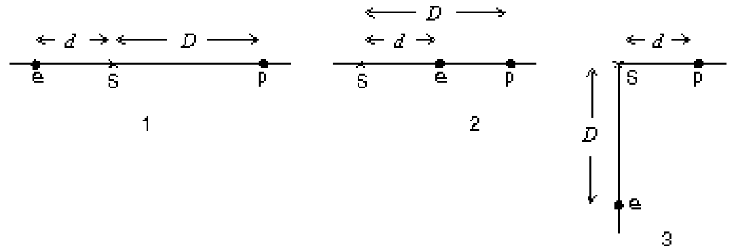
9. In the adjacent figure, an electron is released between two infinite nonconducting sheets that are horizontal and have uniform surface charge densities $\sigma_{(+)}$ and $\sigma_{(-)}$, as indicated. The electron is subjected to the following three situations involving surface charge densities and sheet separations. Rank the magnitudes of the electron's acceleration, greatest first.




| Situation | $\sigma_{(+)}$ | $\sigma_{(-)}$ | Separation |
|---|---|---|---|
| 1 | $+4\sigma$ | $-4\sigma$ | $d$ |
| 2 | $+7\sigma$ | $-\sigma$ | $4d$ |
| 3 | $+3\sigma$ | $-5\sigma$ | $9d$ |

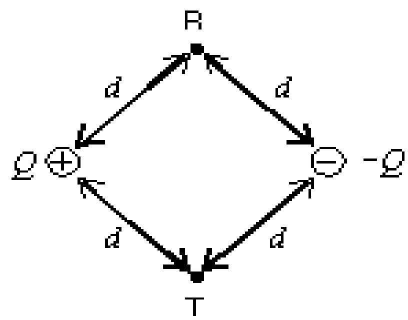
a. 3 > 2 > 1
b. 3 > 1 > 2
c. 1 = 2 = 3
d. 1 > 2 > 3
e. 1 > 3 > 2

10. Three possible configurations for an electron e and a proton p are shown . Take the zero of potential to be at infinity and rank the three configurations according to the potential at S, from most negative to most positive.




a. 1, 2, 3  b. 1 & 3 tie, then 2  c. 3, 2, 1  d. 1 & 2 tie, then 3  e. 2, 3, 1

11. Points R and T are each a distance *d* from each of two particles with charges of equal magnitudes and opposite signs as shown. The work required to move a particle with negative charge *q* from R to T is:




a. Zero  b. $\frac{kqQ}{d^2}$  c. $\frac{kqQ}{d}$

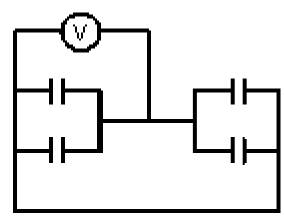
d. $\frac{kqQ}{d^{1/2}}$  e. $\frac{kQq}{2d}$

12. Two conducting spheres have radii of $R_1$ and $R_2$ with $R_1$ greater than $R_2$. If they are far apart the capacitance is proportional to: All full credit. No answer is correct.

a. $\frac{R_1 R_2}{R_1 - R_2}$  b. $R_1^2 - R_2^2$  c. $\frac{R_1 - R_2}{R_1 R_2}$

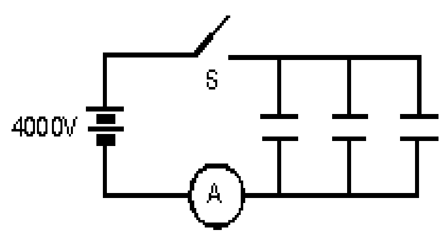
d. $R_2^2 - R_1^2$  e. $R_2^2 + R_1^2$

13. Each of the four capacitors shown is 500 μF. The voltmeter reads 1000V. The magnitude of the charge, in coulombs, on each capacitor plate is:



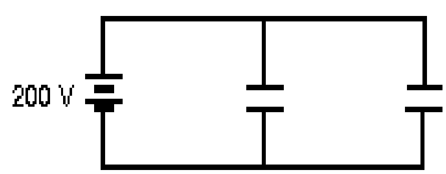

a. 0.2 C  b. 0.5 C  c. 20 C  d. 50 C  e. 100 C

14. Each of the three 25 μF capacitors shown is initially uncharged. How many coulombs of charge pass through the ammeter A after the switch S is closed?




a. 0.10 C  b. 0.30 C  c. 0.05 C
d. 10 C  e. 20 C

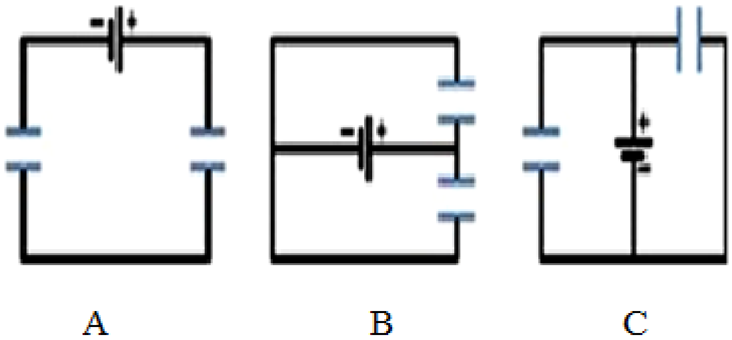
15. To store a total of 0.040 J of energy in two identical capacitors shown, each should have a capacitance of:




a. 2.0 μF  b. 0.50 μF  c. 1.0 μF
d. 1.5 μF  e. 0.10 μF

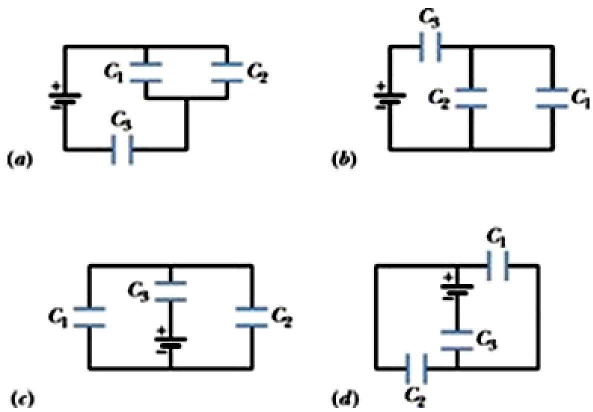
16. Choose which of the following statements is **true** about the circuit configurations shown below.

a. Circuit (c) is neither a series nor a parallel circuit
b. The capacitors of circuit (a) are wired in parallel with the battery.
c. The capacitors of circuit (b) are wired in series with the battery
d. The capacitors of circuit (c) are wired in series with the battery
e. The capacitors of circuit (a) are wired in series with the battery



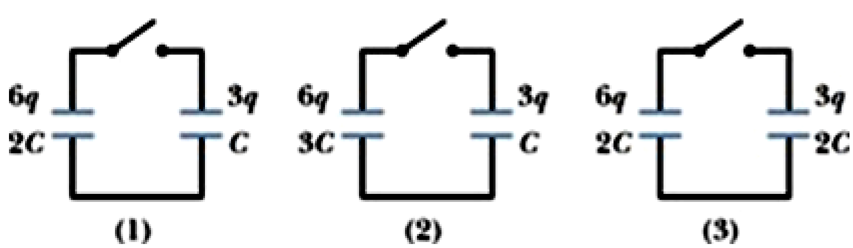

17. Rank the equivalent capacitances of the four circuits shown to the right, greatest first.

a. b > c > d > a     b. a > b >= c > d
c. b = c > a = d     d. a = b = c = d
e. d > c > b > a



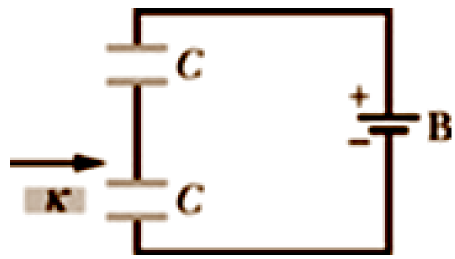

18. After the switches have been closed in the three circuits below, which of the following statements is correct?

a. The charge on the left hand capacitor in circuit (1) increases
b. The charge on the left hand capacitor in circuit (2) decreases
c. The charge on the left hand capacitor in circuit (3) decreases
d. No current flows in circuit (2)
e. No current flows in circuit (3)



19. A dielectric slab (K) is inserted between the plates of one of the two identical capacitors, as shown in the diagram below. Which of the following statements is correct about the capacitor with the dielectric?

a. capacitance increases, charge on capacitor increases, potential difference across capacitor increases
b. capacitance increases, charge on capacitor increases, potential difference across capacitor decreases
c. capacitance increases, charge on capacitor decreases, potential difference across capacitor decreases
d. capacitance increases, charge on capacitor decreases, potential difference across capacitor increases
e. there is no change in capacitance, charge on the capacitor nor potential difference across capacitor




20. Five cylindrical wires are made of the same material. Their lengths and radii are

wire 1: length L; radius $r$

wire 2: length 3L/2; radius $r/2$

wire 3: length L/2; radius $r/2$

wire 4: length L; radius $r/2$

wire 5: length 5L; radius $r/2$

Rank the wires according to their resistances, least to greatest.

a. 1 & 2 tie, then 5, 3, 4
b. 1, 3, 4, 2, 5
c. 1, 2, 3, 4, 5
d. 5, 4, 3, 2, 1
e. 1, 2, 4, 3, 5

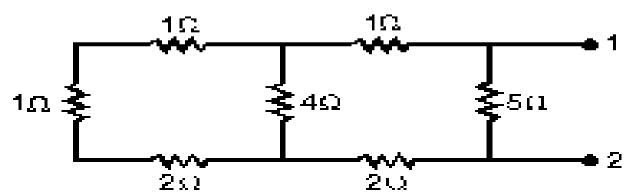
21. A cylindrical copper rod has resistance *R*. It is reformed to twice its original length with no change of volume. Its new resistance is:

a. R b. 2R c. 4R d. 8R e. R/2

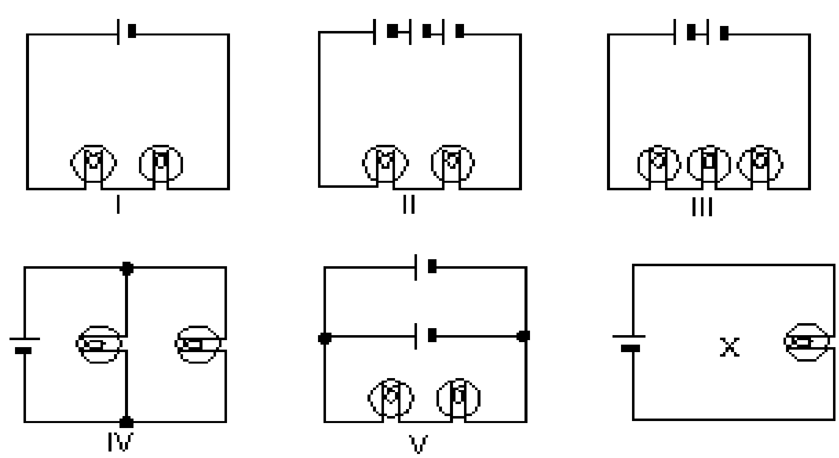
22. It is better to send 10,000 kW of electric power long distances at 10,000 V rather than at 220 V because:
a. The resistance of the wires is less at high voltages
b. More current is transmitted at high voltages
c. The insulation is more effective at high voltages
d. The iR drop along the wires is greater at high voltage
e. There is less heating in the transmission wires

23. Two wires made of the same material have the same length but different diameters. They are connected in series to a battery. The quantity that is 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

24. The equivalent resistance between points 1 and 2 of the circuit below is:
a. 2.5Ω b. 4.5 Ω c. 5.5 Ω d. 6.5 Ω e. 7.5 Ω




25. In the diagrams below, all light bulbs are identical and all emf devices are identical.
In which circuit (I, II, III, IV, V) will the bulbs glow with the same brightness as in circuit X?
a. I b. II c. III d. IV e. V



# Physics C Answer Key: **Orchid Test**
# March12, 2015 (Corrected)

**Record onto the area record the # correct**

| | | | | |
|---|---|---|---|---|
| 1 C | 6 C | 11 A | 16 E | 21 C |
| 2 C | 7 D | 12 A(All full credit) | 17 D | 22 E |
| 3 B | 8 B | 13 B | 18 C | 23 B |
| 4 C | 9 C | 14 B | 19 B | 24 A |
| 5 B | 10 D | 15 C | 20 B | 25 D |

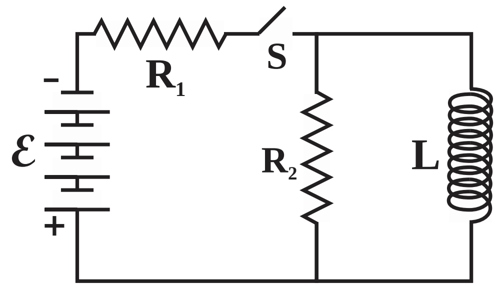
Physics C Science League Test **ORCHID TEST**

April 9, 2015 (Corrected)

**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. Sketches are not to scale. Assume g = 9.8m/s$^2$ and the following moments of inertia:**

**$\mu_o = 4\cdot\pi \times 10^{-7}$ N/A$^2$ $\quad$ $k_m = \mu_o/(4\cdot\pi) = 10^{-7}$ N/A$^2$ $\quad$ $10^4$ Gauss = 1 Tesla**

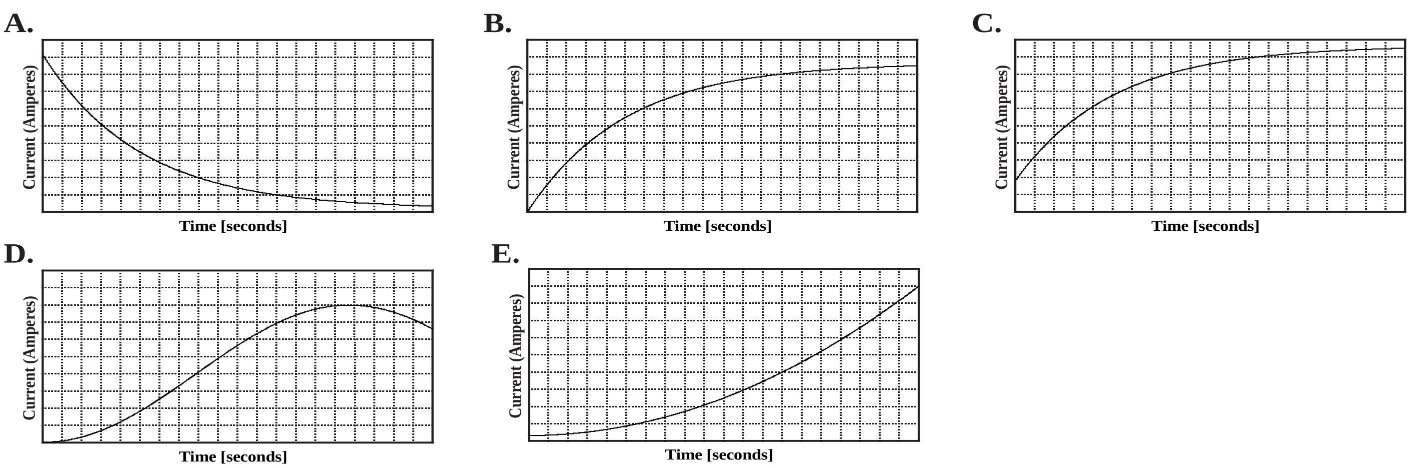
**Questions 1 thr 5 refers to the diagram to the right with resistors $R_1$ and $R_2$, an open switch S and an inductor L. Initially, the switch S is in the open position as shown.**




1. What will be the current flowing through the battery immediately after the switch S has been closed?
   A. $\mathcal{E}/R_1$ B. $\mathcal{E}/(L+R_1)$ C. $\mathcal{E}/(R_1+R_2)$
   D. $\mathcal{E}/(L+R_2)$ E. zero

2. What will be the current flowing through the battery a long time after the switch S has been closed?
   A. $\mathcal{E}/R_1$ B. $\mathcal{E}/(L+R_1)$ C. $\mathcal{E}/(R_1+R_2)$ D. $\mathcal{E}/(L+R_2)$ E. zero

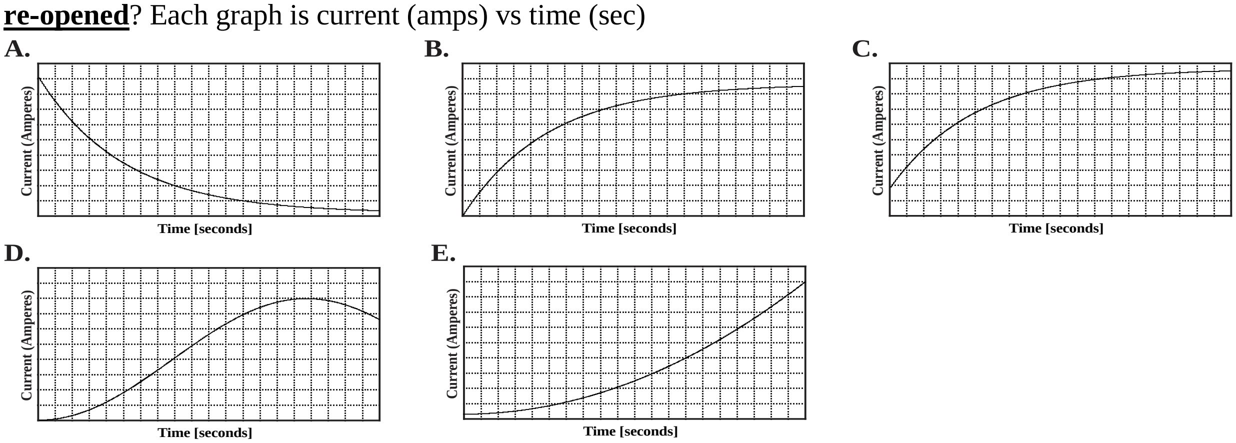
3. Which of the following graphs BEST represents the current through $R_2$ as a function of time after the switch has been closed?



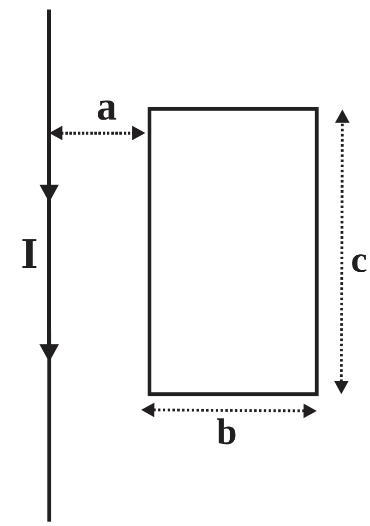

**After switch S has been closed for a long time it is suddenly re-opened.**

4. What will be the potential difference across resistor $R_2$ immediately after the switch S has been reopened?
   A. $\mathcal{E}\cdot(R_2/R_1)$ B. $\mathcal{E}\cdot(R_1+R_2)/R_1$ C. $\mathcal{E}\cdot R_1/(R_1+R_2)$ D. $\mathcal{E}\cdot(R_1-R_2)/(R_1+R_2)$ E. $\mathcal{E}\cdot(R_1+R_2)/(R_1-R_2)$

5. Which of the following graphs BEST represents the current through $R_2$ as a function of time after the switch S has been **re-opened**? Each graph is current (amps) vs time (sec)



**Use the following information for questions 6 and 7. A long straight wire is carrying a conventional current as shown. Adjacent to this straight wire is a rectangular loop. The current in the long, straight wire is increasing with time according to the relationship $I = I_o + \alpha \cdot t$ where $\alpha$ is a positive constant and where $I_o > 0$ is the current at t = 0 sec.**

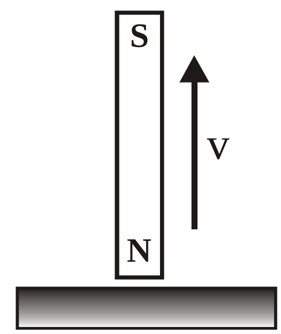



6. What will be the resulting effect on the loop of wire?
   A. There will be a gradually increasing clockwise current flow.
   B. There will be a gradually decreasing clockwise current flowing in the loop.
   C. The loop of wire will be repelled by the long, straight current carrying wire.
   D. There will be a constant counter-clockwise current flowing in the loop.
   E. There will be a gradually decreasing counter-clockwise current flow.

7. Which of the following expressions best describes the magnetic flux through the loop of wire as a function of time?

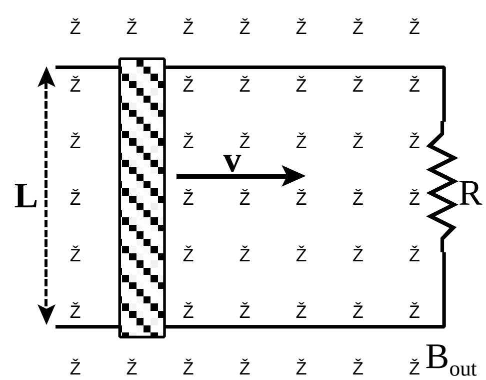
   A. $\frac{\mu_o \cdot (I_o + \alpha t) \cdot c}{2\pi} \cdot \left[\frac{a+b}{b}\right]$ B. $\frac{\mu_o \cdot (I_o + \alpha t)}{2\pi} \cdot \ln\left[\frac{a+b}{b}\right]$

   C. $\frac{\mu_o \cdot (I_o + \alpha t) \cdot c}{2\pi r} \cdot \ln\left[\frac{b}{a+b}\right]$ D. $\frac{\mu_o \cdot (I_o + \alpha t) \cdot c}{2\pi} \cdot \ln\left[\frac{a}{a+b}\right]$ E. $\frac{\mu_o \cdot (I_o + \alpha t) \cdot c}{2\pi} \cdot \ln\left[\frac{a+b}{b}\right]$




8. A bar magnet is oriented as shown and is being lifted quickly away from a sheet of aluminum. Which of the statements correctly describes what will happen?
   A. The bar magnet will feel a net force to the right.
   B. Clockwise eddy currents in the surface of the Aluminum sheet will exert a drag force on the magnet.
   C. There will be no effect since aluminum is not ferromagnetic.
   D. Counter-clockwise eddy currents in the surface of the Aluminum sheet will exert a drag force on the bar magnet.
   E. Eddy currents in the Aluminum sheet will push the bar magnet away from the sheet.

**Consider two parallel, conducting rails connected together at one end by a resistance of R. A movable conducting bar, which has a length L and a mass of M, lies across these two rails and is moving toward the right with a velocity of $v_o$. The entire system is sitting in a uniform magnetic field B which is directed out of the paper as shown.**

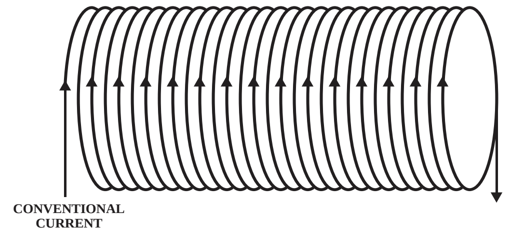



9. What will be the magnitude of the EMF generated across this moving bar?
   A. $B \cdot L^2/t$ B. $B \cdot L \cdot v_o$
   C. $v_o \cdot L/B$ D. $B \cdot L/t$ E. $v_o \cdot L \cdot B/t$

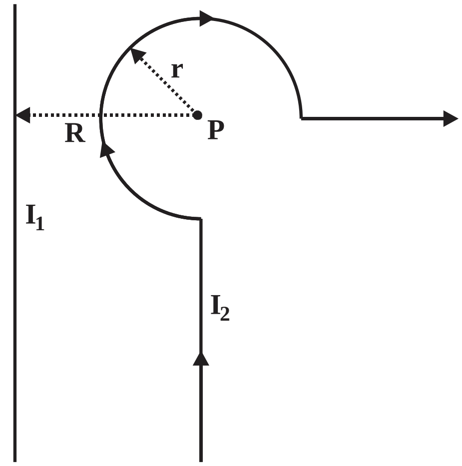
10. At what rate is electrical power being dissipated in the resistance R?
   A. $B \cdot L^2 \cdot v_o/R$ B. $B^2 \cdot L \cdot v_o/R$ C. $B^2 \cdot L^2 \cdot v_o^2/R$
   D. $B^2 \cdot L^2 \cdot v_o^2 \cdot R$ E. $B \cdot L^2 \cdot v_o/2R$

11. How much force would be required to move this bar with this velocity, $v_o$?
   A. $B^2 \cdot L^2 \cdot v_o \cdot R$ B. $B^2 \cdot L^2 \cdot v_o/R$ C. $B^2 \cdot L \cdot v_o/R$
   D. $B \cdot L^2 \cdot v_o \cdot R$ E. $B \cdot L \cdot v_o/R$

12. A solenoid as shown to the right has a self-inductance L. Which of the following changes can be made so as to increase this self-inductance?
A. Increase the length of the solenoid.
B. Add a ferromagnetic core to the solenoid.
C. Add a diamagnetic core to the solenoid.
D. Decrease the permeability within the solenoid.
E. Decrease the number of turns per unit length.




**In the diagram to the right an unknown current of $I_1$ is flowing in a long straight wire, while a current of $I_2$ = 15.0 Amperes is flowing through a loop of wire as shown. [Note that not all of each wire is shown in the diagram, each wire extends off to infinity!] Point P in the diagram is R = 6.00 cm from the long straight wire and r = 3.00 cm from the loop of wire. Use with questions 13, 14, 15, and 16.**



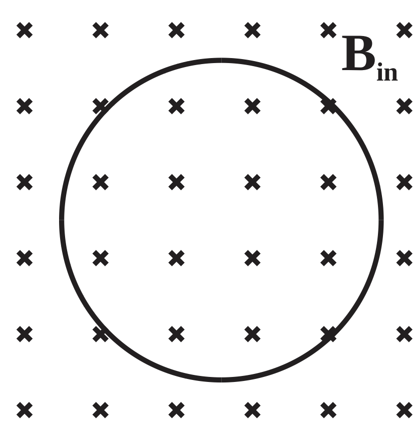

13. The magnetic field at point P caused by current $I_2$ will be directed __________.
A. towards the left side of the page
B. towards the top of the page
C. towards the right side of the page
D. into the page
E. out of the page

14. What will be the magnitude of the magnetic field at point P as caused by current $I_2$?
A. 4.20 Gauss B. 3.10 Gauss C. 18.0 Gauss D. 2.36 Gauss E. 1.10 Gauss

15. What will be the resulting magnetic force on an alpha particle, which has a charge q = 3.2 x $10^{-19}$ C, as it passes through point P with a velocity $v_2 = 2.5 \times 10^6$ m/s directed into the page as caused by the current $I_2$?
A. 2.45 x $10^{-15}$N B. 1.89 x $10^{-16}$N C. 5.22 x $10^{-15}$N D. 4.15 x $10^{-17}$N E. 0.0

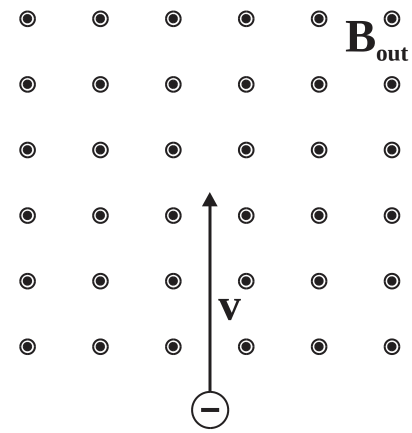
16. What would the current $I_1$ have to be so that the net magnetic field $B_{net}$ at point P is zero?
A. 41 Amperes, towards the bottom of the page
B. 71 Amperes, towards the bottom of the page
C. 35 Amperes, towards the top of the page
D. 41 Amperes, towards the top of the page
E. 35 Amperes, towards the bottom of the page

**The circular wire loop shown to the right has resistance 15.0 Ω and area 1.45 $m^2$, and is fixed in position in the plane of the page. A uniform magnetic field B is directed perpendicularly into the plane of the page. [Assume out of the page is positive!]**




17. The constant rate at which the magnetic field would have to change in order to induce a counter-clockwise current of 2.9 mA in this loop would be
A. -0.030 T/s B. 0.135 T/s C. 0.030 T/s
D. -0.135 T/s E. -0.045 T/s

**A negatively charged sulfur ion, which has a mass of $5.33 \times 10^{-26}$ kg and a charge of $q = -3.20 \times 10^{-19}$C, enters a magnetic field of $B = 2.20$ Tesla directed out of the page as shown with a velocity of $v = 6.00 \times 10^{4}$ m/s.**



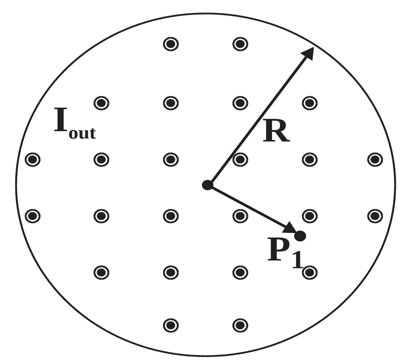

18. What will be the direction of the magnetic force on this sulfur ion just as it enter the magnetic field?
    A. into the page B. out of the page C. towards the top of the page
    D. towards the left E. towards the right

19. What will be the radius of the resulting path of the sulfur ion as it moves through the magnetic field?
    A. 3.28 mm B. 5.50 mm C. 15.2 mm D. 4.54 mm E. 8.10 mm

20. In what direction should an electric field E be added to the magnetic field so that the sulfur ion will pass through the magnetic field without being deflected?
    A. into the page B. out of the page C. towards the top of the page
    D. towards the left E. towards the right

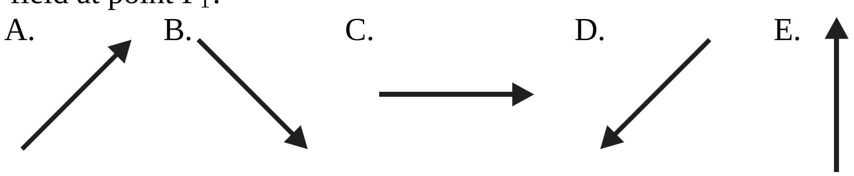
21. What would be the magnitude of the electric field E so that the sulfur ion will pass through the magnetic field **without** being deflected?
    A. $4.55 \times 10^{5}$ N/C B. $8.25 \times 10^{6}$ N/C C. $7.05 \times 10^{5}$ N/C D. $3.25 \times 10^{6}$ N/C E. $1.32 \times 10^{5}$ N/C

**Consider a wire as shown to the right within which there is a non-uniform current flowing out of the page with a current density given by $J = \alpha + \beta r$ where $\alpha$ and $\beta$ are positive constants and r is the distance from the center of the wire.**




**End View of Wire**

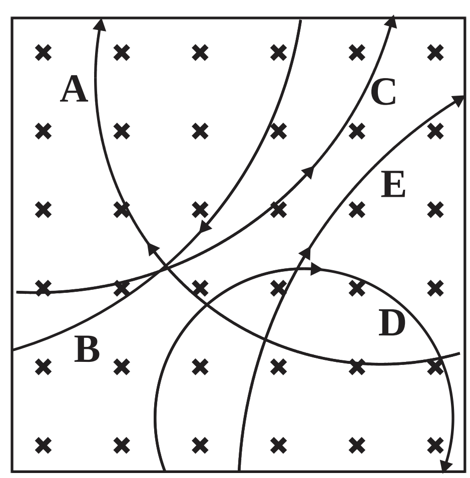
22. Which of the following vectors best points in the direction of the magnetic field at point $P_1$?




23. What will be the total current flowing through this wire?
    A. $\pi R^2(\alpha+\beta R)$ B. $2\pi R(\alpha+\beta R)$ C. $2\pi R^2(\alpha/2+\beta R/3)$
    D. $2\pi(\alpha R^3/3+\beta R^4/4)$ E. $2\pi R^2(\alpha+\beta R)$

24. What will be the magnitude of the magnetic field B at point $P_1$?
    A. $\mu_o r(\alpha/2+\beta r/3)$ B. $\mu_o R^2(\alpha/2+\beta r/3)$ C. $\mu_o r^2(\alpha/2+\beta r^2/3)$
    D. $\mu_o r(\alpha/2+\beta r^3/3)$ E. $\mu_o r(\alpha/2+\beta r^2/3)$

**The figure to the right shows the paths of five particles as they pass through the region inside the box that contains a uniform magnetic field B directed into the page.**




25. Which particle has a positive charge?
    A. A B. B C. C D. D E. E

# Physics C Answer Key: **Orchid Test**

## April 9, 2015

**Record onto the area record the % correct** (Corrected)

| | | | | |
|---|---|---|---|---|
| 1 C | 6 C | 11 B | 16 B | 21 E |
| 2 A | 7 E(all full credit) | 12 B& A | 17 A | 22 A |
| 3 A | 8 B | 13 D | 18 D | 23 C |
| 4 A | 9 B | 14 D | 19 D | 24 A |
| 5 A | 10 C | 15 E | 20 D | 25 C |