Physics C Science League Test <u>Orchid</u>
January 12, 2017 Corrections #12 C

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. **<u>Assume g = -9.8m/s^2</u>** and the following moments of inertia:

1. A boat that can travel at 4.0 km/h in still water crosses a river with a current of 2.0 km/h. At what angle must the boat be pointed upstream (that is, relative to its actual path) to go straight across the river?

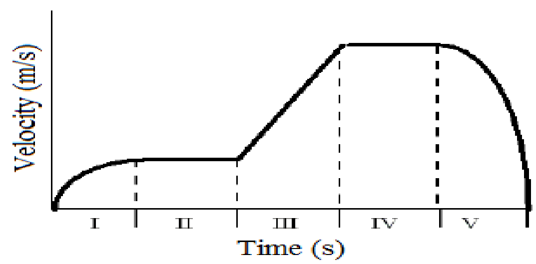
A. 27^0
B. 90^0
C. 30^0
D. 63^0
E. 60^0

2. A particle is subjected to a conservative force whose potential energy function is
$U(x)=(x-2)^3-12x$ where U is given in Joules when x is measured in m. Which of the following represents a position of stable equilibrium?

A. x= -4
B. x= -2
C. x= 0
D. x= 2
E. x= 4

3. A 2.0-kg object moves in a straight line on a horizontal frictionless surface.
The graph shows the velocity of the object as a function of time. The various equal time intervals are labeled using Roman numerals: I, II, III, IV, and V. The net force on the object always acts along the line of motion of the object. In which section of the graph is the magnitude of the net force decreasing?

A. I
B. II
C. III
D. IV
E. V



4. When a certain spring is stretched a distance A, it exerts a restoring force $F = ax + bx^2$, where a and b are constants. The work done in stretching this spring from x = 0 to x = L is:

A. $aL^2 + 2bLx^3$
B. $aL + 2bLx^2$
C. $a + bL$
D. bL
E. $1/2\ aL^2 + 1/3\ bL^3$

5. A crate rests on the flatbed of a truck that is initially traveling at 15 m/s on a level road. The driver applies the brakes and the truck is brought to a halt in a distance of 38 m. If the deceleration of the truck is constant, what is the minimum coefficient of friction between the crate and the truck that is required to keep the crate from sliding?

A. 0.59
B. This cannot be determined without knowing the mass of the crate
C. 0.20
D. 0.30
E. 0.39

6. In an amusement park ride, a child stands against the wall of a cylindrical room that is then made to rotate. The floor drops downward and the child remains pinned against the wall. If the radius of the room is 2.15 m and the relevant coefficient of friction between the child and the wall is 0.600, with what minimum speed is the child moving, if he is to remain pinned against the wall?

A. 0.93 m/s
B. 5.93 m/s
C. 12.1 m/s
D. 9.8 m/s
E. 7.26 m/s

7. As a rock of mass 4kg drops from the edge of a 40m high cliff, it experiences air resistance, whose average strength during the descent is 20N. At what speed will the rock hit the ground?

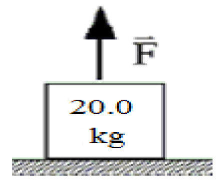
A. 8m/s
B. 10m/s
C. 12m/s
D. 16m/s
E. 20m/s

8. An airplane flying at 115 m/s due east makes a gradual turn following a circular path to fly south. The turn takes 15 seconds to complete. What is the radius of the curve that the plane follows in making the turn?

A. 350 m
B. 830 m
C. 280 m
D. 1100 m
E. 1600 m

9. A rope exerts a force F on a 20.0-kg crate. The crate starts from rest and accelerates upward at 5.00 m/s^2 near the surface of the earth. What is the kinetic energy of the crate when it is 4.0 m above the floor?

A. 1180 J
B. 704 J
C. 250 J
D. 400 J
E. 116 J



10. The figure shown below is a view from above of two clay balls moving toward each other on a frictionless surface. All angles given in degrees. They collide perfectly inelastically at the indicated point and are observed to move in the direction indicated by the post collision velocity vector V'. If m1=2m2, what is v2?

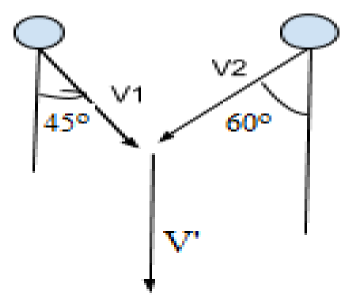
A. V1(sin45)/(2sin60)

B. V1(cos45)/(2cos60)

C. V1(2cos45)/(cos60)

D. V1(2sin45)/(sin60)

E. V1(cos45)/(2sin60)

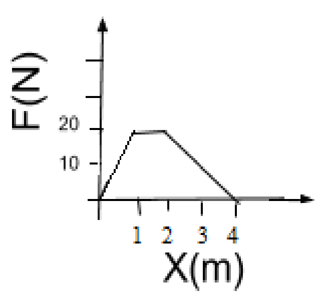


11. A projectile is launched with a momentum of 200 kg •m/s and 1000 J of kinetic energy. What is the mass of the projectile?

A. 50 kg
B. 20 kg
C. 40 kg
D. 5 kg
E. 10 kg

12. A particle of mass m=1.0kg is acted upon by a variable force, F(x), whose strength is given by the graph below. If the particle's speed was zero at x=0, what is its speed at x=4m? C is correct not D

A. 5m/s
B. 8.7m/s
C. 10m/s
D. 14m/s
E. 20m/s



13. The force on a 6kg object is given by the equation: $F(x)=3x+5$, in Newtons. The object is moving 2m/s at the origin. The **work** done on the object by the force when it is moved 4m from the origin in the x direction is :

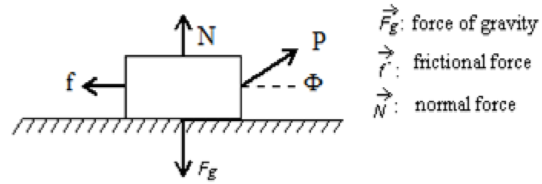
A. 44 J
B. 72 J
C. 36 J
D. 22 J
E. 144

14. Two objects slide over a frictionless horizontal surface. The first object m_1=5kg, is propelled with speed 4.5m/s toward the second object m_2=2.5kg, which is initially at rest. After the collision both objects have velocities which are directed q=30degree on either side of the original line of motion of the first object. What is the final speed of object 2?

A. 2.598 m/s
B. 5.1962 m/s
C. 22.5m/s
D. 11.25m/s
E. 28.125m/s

15. A man pulls a wooden box along a rough horizontal floor at constant speed by means of force ***P*** as shown below. In the diagram, ***f*** is the magnitude of the friction force, ***N*** is the magnitude of the normal force and $\boldsymbol{F_g}$ 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

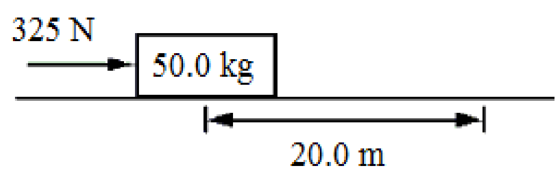


16. A constant force of 25 N is applied as shown to a block which undergoes a displacement of 7.5 m to the right along a frictionless surface while the force acts. What is the **work** done by the force?

A. 94 J
B. 0 J
C. 160 J
D. -162 J
E. -94 J

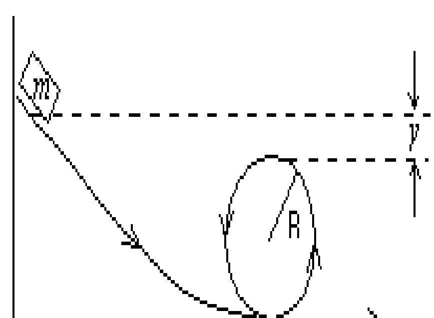
17. What coefficient of friction would be required to keep the box moving at constant speed under the action of the 325-N force?

A. 0.321
B. 0.508
C. 0.250
D. 0.663
E. 0.747



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

A. R/4
B. R/2
C. R
D. 2R
E. zero



19. A block is dropped from a high tower and is falling freely under the influence of gravity. Which one of the following statements is true concerning this situation? Neglect air resistance

A. As the block falls, the net work done by all of the forces acting on the block is zero joules
B. The potential energy of the block decreases by equal amounts in equal times
C. The kinetic energy increases by equal amounts over equal distances
D. The kinetic energy of the block increases by equal amounts in equal times
E. The total energy of the block increases by equal amounts over equal distances

20. A 2.0-kg projectile is fired with initial velocity components v_{ox} = 30 m/s and v_{oy} = 40 m/s from a point on the earth's surface. Neglect any effects due to air resistance. How much work was done in firing the projectile?

A. 2500 J
B. 4900 J
C. 900 J
D. 9800 J
E. 1600 J

21. A 10.0-g bullet traveling horizontally at 755 m/s strikes a stationary target and stops after penetrating 14.5 cm into the target. What is the average force of the target on the bullet?

A. 6.26×10^3 N
B. 3.13×10^4 N
C. 3.93×10^4 N
D. 1.97×10^4 N
E. 2.07×10^5 N

22. A turtle takes 3.5 minutes to walk 18 m toward the south along a deserted highway. A truck driver stops and picks up the turtle. The driver takes the turtle to a town 1.1 km to the north with an average speed of 12 m/s. What is the magnitude of the average velocity of the turtle for its entire journey?

A. 6.0 m/s
B. 9.8 m/s
C. 3.6 m/s
D. 11 m/s
E. 2.6 m/s

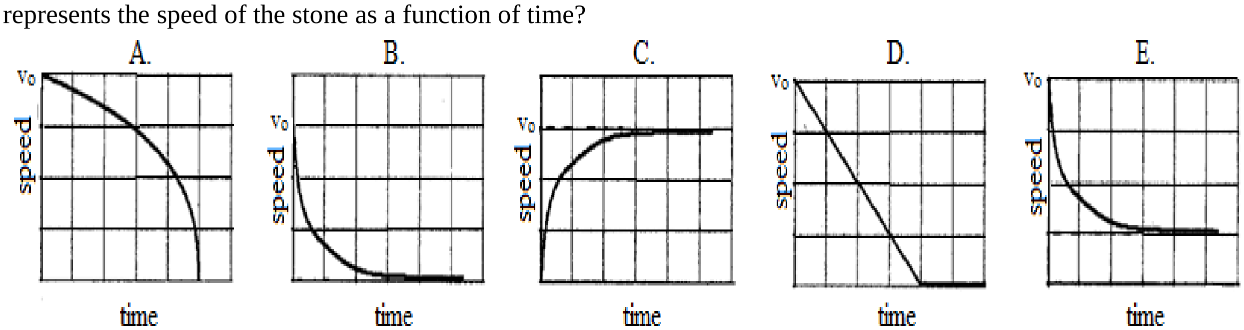
23. Two cars travel along a level highway. It is observed that the distance between the cars is *increasing*. Which one of the following statements concerning this situation is *necessarily* true? C is the only possibility. I would replace the word necessarily with could be true. Necessarily leads to ambiguity.

A. At least one of the cars has a *non-zero* acceleration
B. The leading car has the greater acceleration
C. Both cars could be accelerating at the same rate
D. The trailing car has the smaller acceleration
E. The velocity of each car is increasing

24. A rock of mass **m** is dropped straight down into a pond. Its initial speed in the water is v_0 and the drag force in the water is proportional to its speed at any time during the plunge with a proportionality coefficient **b**. What is the terminal velocity of the stone?

A. mg B. 3m/b C. 3b/m D. mgb E. mg/b

25. Assuming the stone's initial speed is greater than its terminal speed, which of the following graphs correctly represents the speed of the stone as a function of time?



AP Physics C Formulae

MECHANICS

$v = v_0 + at$

$x = x_0 + v_0 t + \frac{1}{2}at^2$

$v^2 = v_0^2 + 2a(x - x_0)$

$\sum \mathbf{F} = \mathbf{F}_{net} = m\mathbf{a}$

$\mathbf{F} = \frac{d\mathbf{p}}{dt}$

$\mathbf{J} = \int \mathbf{F}\,dt = \Delta\mathbf{p}$

$\mathbf{p} = m\mathbf{v}$

$F_{fric} \le \mu N$

$W = \int \mathbf{F} \cdot d\mathbf{r}$

$K = \frac{1}{2}mv^2$

$P = \frac{dW}{dt}$

$P = \mathbf{F} \cdot \mathbf{v}$

$\Delta U_g = mgh$

$a_c = \frac{v^2}{r} = \omega^2 r$

$\boldsymbol{\tau} = \mathbf{r} \times \mathbf{F}$

$\sum \boldsymbol{\tau} = \boldsymbol{\tau}_{net} = I\boldsymbol{\alpha}$

$I = \int r^2 dm = \sum mr^2$

$\mathbf{r}_{cm} = \sum m\mathbf{r} / \sum m$

$v = r\omega$

$\mathbf{L} = \mathbf{r} \times \mathbf{p} = I\boldsymbol{\omega}$

$K = \frac{1}{2}I\omega^2$

$\omega = \omega_0 + \alpha t$

$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$

a = acceleration
F = force
f = frequency
h = height
I = rotational inertia
J = impulse
K = kinetic energy
k = spring constant
ℓ = length
L = angular momentum
m = mass
N = normal force
P = power
p = momentum
r = radius or distance
$\mathbf{r}$ = position vector
T = period
t = time
U = potential energy
v = velocity or speed
W = work done on a system
x = position
μ = coefficient of friction
θ = angle
τ = torque
ω = angular speed
α = angular acceleration
ϕ = phase angle

$\mathbf{F}_s = -k\mathbf{x}$

$U_s = \frac{1}{2}kx^2$

$x = x_{max}\cos(\omega t + \phi)$

$T = \frac{2\pi}{\omega} = \frac{1}{f}$

$T_s = 2\pi\sqrt{\frac{m}{k}}$

$T_p = 2\pi\sqrt{\frac{\ell}{g}}$

$\mathbf{F}_G = -\frac{Gm_1m_2}{r^2}\hat{\mathbf{r}}$

$U_G = -\frac{Gm_1m_2}{r}$

ELECTRICITY AND MAGNETISM

$F = \frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{r^2}$

$\mathbf{E} = \frac{\mathbf{F}}{q}$

$\oint \mathbf{E} \cdot d\mathbf{A} = \frac{Q}{\epsilon_0}$

$E = -\frac{dV}{dr}$

$V = \frac{1}{4\pi\epsilon_0}\sum_i \frac{q_i}{r_i}$

$U_E = qV = \frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{r}$

$C = \frac{Q}{V}$

$C = \frac{\kappa\epsilon_0 A}{d}$

$C_p = \sum_i C_i$

$\frac{1}{C_s} = \sum_i \frac{1}{C_i}$

$I = \frac{dQ}{dt}$

$U_c = \frac{1}{2}QV = \frac{1}{2}CV^2$

$R = \frac{\rho\ell}{A}$

$\mathbf{E} = \rho\mathbf{J}$

$I = Nev_d A$

$V = IR$

$R_s = \sum_i R_i$

$\frac{1}{R_p} = \sum_i \frac{1}{R_i}$

$P = IV$

$\mathbf{F}_M = q\mathbf{v} \times \mathbf{B}$

A = area
B = magnetic field
C = capacitance
d = distance
E = electric field
ε = emf
F = force
I = current
J = current density
L = inductance
ℓ = length
n = number of loops of wire per unit length
N = number of charge carriers per unit volume
P = power
Q = charge
q = point charge
R = resistance
r = distance
t = time
U = potential or stored energy
V = electric potential
v = velocity or speed
ρ = resistivity
ϕ_m = magnetic flux
κ = dielectric constant

$\oint \mathbf{B} \cdot d\boldsymbol{\ell} = \mu_0 I$

$d\mathbf{B} = \frac{\mu_0}{4\pi}\frac{I\,d\boldsymbol{\ell} \times \mathbf{r}}{r^3}$

$\mathbf{F} = \int I\,d\boldsymbol{\ell} \times \mathbf{B}$

$B_s = \mu_0 nI$

$\phi_m = \int \mathbf{B} \cdot d\mathbf{A}$

$\varepsilon = \oint \mathbf{E} \cdot d\boldsymbol{\ell} = -\frac{d\phi_m}{dt}$

$\varepsilon = -L\frac{dI}{dt}$

$U_L = \frac{1}{2}LI^2$

AP Physics C Formulae

GEOMETRY AND TRIGONOMETRY

Rectangle

$A = bh$

Triangle

$A = \frac{1}{2}bh$

Circle

$A = \pi r^2$

$C = 2\pi r$

Rectangular Solid

$V = \ell wh$

Cylinder

$V = \pi r^2 \ell$

$S = 2\pi r\ell + 2\pi r^2$

Sphere

$V = \frac{4}{3}\pi r^3$

$S = 4\pi r^2$

A = area
C = circumference
V = volume
S = surface area
b = base
h = height
ℓ = length
w = width
r = radius

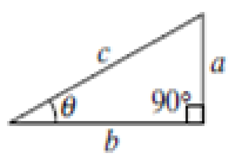
Right Triangle

$a^2 + b^2 = c^2$

$\sin\theta = \frac{a}{c}$

$\cos\theta = \frac{b}{c}$

$\tan\theta = \frac{a}{b}$



CALCULUS

$$\frac{df}{dx} = \frac{df}{du}\frac{du}{dx}$$

$$\frac{d}{dx}\left(x^n\right) = nx^{n-1}$$

$$\frac{d}{dx}\left(e^x\right) = e^x$$

$$\frac{d}{dx}(\ln x) = \frac{1}{x}$$

$$\frac{d}{dx}(\sin x) = \cos x$$

$$\frac{d}{dx}(\cos x) = -\sin x$$

$$\int x^n\,dx = \frac{1}{n+1}x^{n+1},\ n \neq -1$$

$$\int e^x\,dx = e^x$$

$$\int \frac{dx}{x} = \ln|x|$$

$$\int \cos x\,dx = \sin x$$

$$\int \sin x\,dx = -\cos x$$

Physics C Answer Key: **Orchid Test**
Date Jan 12, 2017

Solutions Corrections #12 is C

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

JANUARY: kinematics in one and two dimensions; Newton's laws including resistance forces and dynamics of circular motion; vector algebra (mostly assumed as needed); energy and its conservation including potential energy and conservative forces, momentum and its conservation including two-dimensional situations

FEBRUARY: angular mechanics including rotational equilibrium, rotational dynamics, rotational energy, and angular momentum; oscillatory motion including kinematics, dynamics, energy, and damping; gravitation including kinematics and dynamics of planetary motion, angular momentum, and energy as applied to gravitation. Plus Jan topics

MARCH: electrostatics including electrostatic forces, electrostatic field, electrostatic field flux and Gauss's Law; electrostatic potential and potential energy; dc electrical circuits including multi-loop circuits and power; capacitors, dielectrics, and circuits with capacitors. Plus Jan and Feb Topics.

APRIL: Magnetic Fields and Forces including the applications of the Lorenz force, the Law of Biot-Savart, Ampere's Law, magnetic field flux and Faraday's Law, Lenz's Law for electromagnetic induction; magnetic materials, applications of electromagnetic induction, and circuits with inductors. Plus Jan, Feb, and March topics.

Dates for 2017 Season

Thursday January 12, 2017 Thursday February 9, 2017

Thursday March 9, 2017 Thursday April 13, 2017

All schools must complete the April exam and mail in the results by April 28th, 2017

New Jersey Science League

PO Box 65 Stewartsville, NJ 08886-0065

phone # 908-213-8923 fax # 908-213-9391 email: **newjsl@ptd.net**

Web address: **http://entnet.com/~personal/njscil/html/**

What is to be mailed back to our office?

PLEASE RETURN THE AREA RECORD AND ALL TEAM MEMBER SCANTRONS (ALL STUDENTS PLACING 1ST, 2ND, 3RD, AND 4TH).

If you return scantrons of alternates, then label them as ALTERNATES.

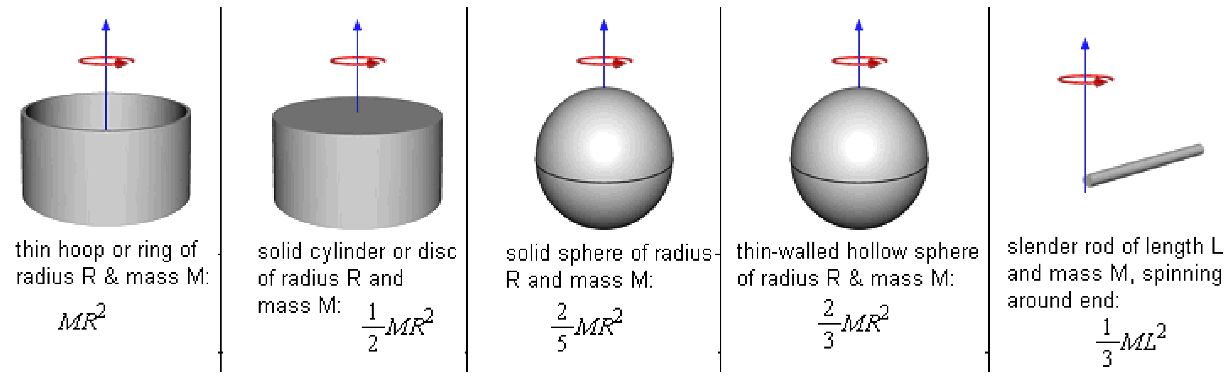
Dates 2018 Season

Thursday January 11, 2018 Thursday February 8, 2018

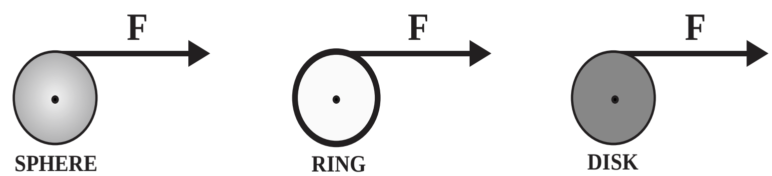
Thursday March 8, 2018 Thursday April 12, 2018

Physics C Science League Test **Orchid** **No Corrections**
Feb 9, 2017

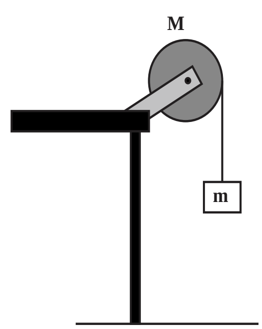
DIRECTIONS: Please PRINT your name, school, area, and which test you are taking on the Scantron supplied. For each statement or question, completely fill in the appropriate space on the answer sheet. Use the letter preceding the word or phrase or sketch which best completes the statement or answers the question. Unless stated otherwise assume ideal conditions including no friction. Sketches are not to scale. Assume g = 10m/s^2 and the following moments of inertia:



1. A solid uniform disk, a thin ring, and a solid uniform sphere, all with the same mass and the same outer radius, are each free to rotate about a fixed axis through its center. Assume that the ring is connected to the rotation axis by light spokes. With the objects starting from rest, identical forces **F** are simultaneously applied to the rims, as shown. Rank the objects according to their kinetic energies after the force **F** has been applied for a given time **t**, from greatest to least.
   A. disk, ring, sphere
   B. sphere, disk, ring
   C. ring, sphere, disk
   D. disk, sphere, ring
   E. ring, disk, sphere



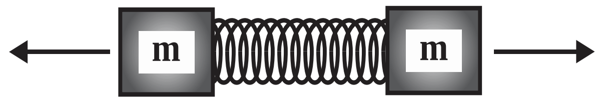
2. A "super ball" is dropped from a height of 2.0 meters onto a solid surface and rebounds elastically. The resulting motion of the ball will be ___________.
   A. simple harmonic with a period of 0.63 seconds.
   B. simple harmonic with a period of 1.26 seconds.
   C. periodic with an amplitude of 1.5 meters.
   D. simple harmonic with an amplitude of 2.0 meters.
   E. periodic with a period of 1.26 seconds.



3. A uniform disk (I =½ MR^2) of mass **M = 4m** can rotate without friction on a fixed axis as shown to the right. A string is wrapped around its circumference and is attached to a mass **m**. The string does not slip. What is the tension in the cord while the mass is falling?
   A. mg B. ½ mg C. $^2/_5$ mg D. $^3/_2$ mg E. $^2/_3$ mg

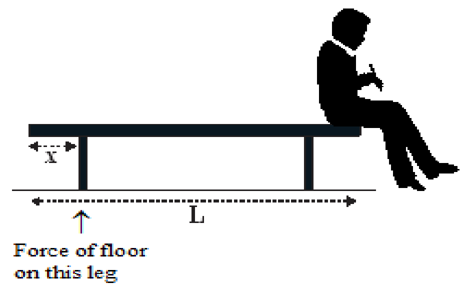
4. Two equal masses **m** are attached to the opposite ends of a spring that has a spring constant **k**. The entire system is initially at rest on a frictionless surface. Each mass is then pulled outward in opposite directions and is then released. What will be the resulting period of oscillation of the system?

A. $2\pi\sqrt{m/k}$ B. $2\pi\sqrt{2m/k}$ C. $2\pi\sqrt{m/2k}$
D. $\sqrt{k/m}$ E. $\sqrt{3m/2k}$



5. A student, who has a mass of **m** = 48 kg, is sitting on the end of a bench which consists of a horizontal board which has a length of **L** = 2.0 meters and a mass of **M** = 14 kg plus two legs, each with a mass of 2.0kg, located **x** = 25 cm from the ends of the bench. What will be the magnitude of the force exerted by the floor on the left most leg?

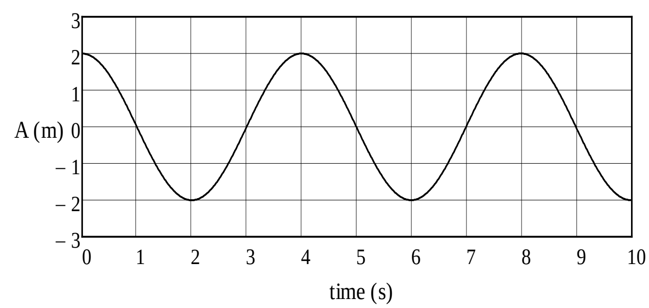
A. 5.0N B. 10N C. 30N D. 45N E. 60N



6. A spinning object begins from rest and accelerates to an angular velocity of ω = 30 rad/s with an angular acceleration of α = 6.0 rad/s^2. It then remains spinning at that constant angular velocity for 10 seconds after which an external frictional torque brings the object to rest after an additional 20 seconds. Through what total angular displacement did the object rotate?

A. 1050 rad B. 675 rad C. 440 rad D. 2100 rad E. 880 rad

A M = 8.0 kg mass is attached to the end of a spring which has a spring constant k and is oscillating horizontally on a frictionless surface. The displacement of the mass as a function of time is shown on the graph to the right.



7. What is the spring constant of this spring?

A. 4.4 N/m B. 7.6 N/m C. 19.7 N/m
D. 24.5 N/m E. 33.3 N/m

8. What is the total mechanical energy content of this oscillating system?

A. 2.2 J B. 18.3 J C. 39.5 J D. 52.2 J E. 103 J

9. At which of the following times will the speed of this oscillating mass be maximum?

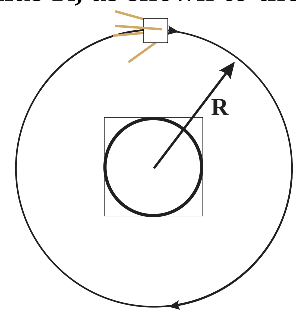
A. 2.0 s B. 4.3 s C. 2.5 s D. 3.0 s E. 0.0 s

A very small mass m is gently placed on top of the oscillating mass M at the moment the oscillating mass is at its maximum displacement from equilibrium.

10. What is the minimum coefficient of static friction μ_s between the two masses, if the small mass **m** is to remain at rest relative to the larger mass as it oscillated back and forth?

A. 0.22 B. 0.49 C. 0.55 D. 0.71 E. 0.84

A spacecraft, which has a mass of m = 55 kg, orbits Earth in a circular orbit of radius R, as shown to the right. [m_{earth} = 5.97 x 10^{24}kg, R_{earth} = 6.37 x 10^6 m, G = 6.67 x $10^{-11}$$Nm^2/kg^2$]



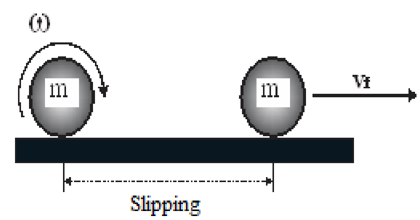
11. At what altitude above the Earth's surface should the satellite orbit in order for the satellite to orbit the Earth once every 24 hours [geosynchronous orbit]?
    A. 6.2 x 10^6m B. 8.2 x 10^6m C. 1.13 x 10^7m
    D. 2.72 x 10^7m E. 3.6 x 10^7m

12. What will be the gravitational acceleration **g** at the location of this satellite?
    A. 4.2 m/s^2 B. 1.8 m/s^2 C. 0.70 m/s^2 D. 0.22 m/s^2 E. 0.0 m/s^2

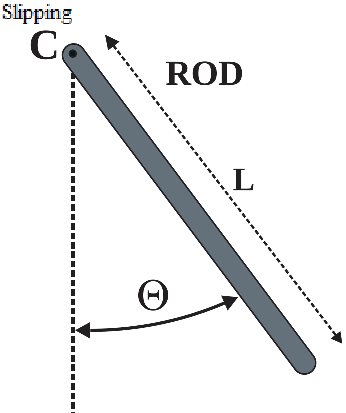
13. How much energy would have to be added to this orbiting satellite if it is to escape the Earth to never return?
    A. 1.3 x 10^8J B. 2.6 x 10^8J C. 3.9 x 10^8J D. 4.2 x 10^8J E. 6.3 x 10^8J

14. A bowling ball, which has a mass **m** and a radius **R**, is rotating with an angular velocity **ω** when it is released gently on to a bowling alley which has a coefficient of kinetic friction μ_k. What will be the linear velocity $\mathbf{v_f}$ of the ball when it finally begins rolling without slipping?

    A. ½ ωR B. $^2/_7$ ωR C. $^3/_5$ ωR D. ¼ ωR E. $^3/_2$ ωR



A uniform rod that has a length L and mass m is displaced to an angle Θ = 60° from the vertical as shown and is then released. [15 & 16]



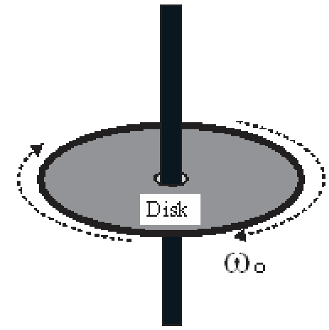
15. What will be the linear velocity of the bottom end of the rod when the rod becomes vertical?
    A. $\sqrt{\frac{5}{2}gL}$ B. $\sqrt{\frac{3}{4}gL}$ C. $\sqrt{\frac{3}{2}gL}$ D. $\sqrt{\frac{3}{4}g(L+cos\Theta)}$ E. $\sqrt{\frac{2}{3}g(L-cos\Theta)}$

This rod is then displaced slightly from equilibrium and is then released.

16. What will be the period of oscillation of this physical pendulum?
    A. $2\pi\sqrt{\frac{2L}{3g}}$ B. $2\pi\sqrt{\frac{L}{3g}}$ C. $2\pi\sqrt{\frac{3L}{4g}}$ D. $2\pi\sqrt{\frac{2L}{5g}}$ E. $2\pi\sqrt{\frac{L}{5g}}$

17. Our own Sun has a mass of 1.99 x 10^{30}kg, a radius of 6.96 x 10^8m and a rotational period of 26.47 earth days. At some point, long in the future, our Sun will first expand into a red giant phase and will eventually settle into a brown dwarf phase. Assume that when the Sun becomes a brown dwarf, its radius is reduced to 5.2 x 10^5m. What would be the resulting rotational period of the Sun?
    A. 1.28 sec B. 3.30 sec C. 4.25 sec D. 42.5 sec E. 91.2 sec

A uniform disk, which has a mass m = 3.0 kg and radius R = 20 cm, is rotating clockwise about a shaft through its center with an initial angular velocity of ω_o = 90 rad/s as shown to below.



18. What would be the <u>magnitude and direction</u> of the external rotational impulse required to bring this disk to rest?

A. 12 kgm^2/s down B. 12 kgm^2/s up C. 5.4 kgm^2/s up
D. 6.0 kgm^2/s down E. 3.0 kgm^2/s down

19. How much work would need to be done by the external torque to bring the disk to rest?

A. 135 J B. 162 J C. 204 J D. 243 J E. 311 J

Suppose that an external drag torque dependent on the angular velocity of the disk given by

$T = -\beta\omega$ is applied to the disk so as to bring it to rest where the drag coefficient is β = 0.020 Nms.

20. What will be the angular acceleration α of the disk as it is brought to rest?
A. $-9e^{-3t}$ B. $2.7e^{-t/3}$ C. $-30e^{-t/3}$ D. $-54e^{-t/9}$ E. $-9e^{-t/9}$

21. Through what angle will the disk rotate while it is being brought to rest?
A. 60 rad B. 270 rad C. 320 rad D. 420 rad E. 455 rad

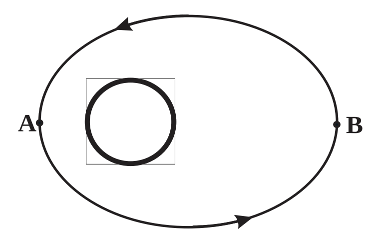
Consider a non-uniform disk which has a radius R = 20 cm. and an area mass density σ that varies according to the relationship $\sigma = (150 + 300r^2)$ kg/m^2.

22. What is the total mass of this disk?
A. 4.0 kg B. 6.3 kg C. 8.2 kg D. 8.9 kg E. 19.6 kg

23. What will be the moment of inertia of this non-uniform disk about an axis perpendicular to and through the center of mass of the disk?
A. 1.223 kgm^2 B. 1.110 kgm^2 C. 1.045 kgm^2 D. 0.397 kgm^2 E. 0.223 kgm^2

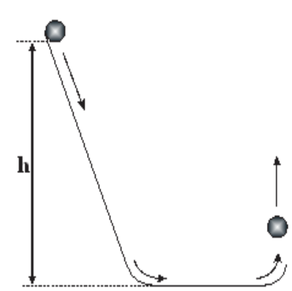
24. A satellite travels around the Earth in an elliptical orbit as shown. As the satellite travels from point A to point B. which of the following is true about its speed and angular momentum?

<u>Speed</u>	<u>Angular Momentum</u>
A. Increases	Decreases
B. Remains Constant	Increases
C. Decreases	Remains constant
D. Remains Constant	Remains Constant
E. Increases	Increases



25. A ring is initially at rest at the top of an incline at a height **h** above the lowest point. The ring is then released and rolls down the incline without slipping, moves along the horizontal surface until it reaches a **small** circular lip which tosses the ring vertically upward. What is the maximum height reached by the ring?

A. h B. ½ h C. $^1/_3$ h D. $^2/_3$ h E. $^2/_5$ h



Physics C Answer Key: **Orchid Test**

Date Feb 9, 2017 No Corrections

Solutions

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

JANUARY: kinematics in one and two dimensions; Newton's laws including resistance forces and dynamics of circular motion; vector algebra (mostly assumed as needed); energy and its conservation including potential energy and conservative forces, momentum and its conservation including two-dimensional situations

FEBRUARY: angular mechanics including rotational equilibrium, rotational dynamics, rotational energy, and angular momentum; oscillatory motion including kinematics, dynamics, energy, and damping; gravitation including kinematics and dynamics of planetary motion, angular momentum, and energy as applied to gravitation. Plus Jan topics

MARCH: electrostatics including electrostatic forces, electrostatic field, electrostatic field flux and Gauss's Law; electrostatic potential and potential energy; dc electrical circuits including multi-loop circuits and power; capacitors, dielectrics, and circuits with capacitors. Plus Jan and Feb Topics.

APRIL: Magnetic Fields and Forces including the applications of the Lorenz force, the Law of Biot-Savart, Ampere's Law, magnetic field flux and Faraday's Law, Lenz's Law for electromagnetic induction; magnetic materials, applications of electromagnetic induction, and circuits with inductors. Plus Jan, Feb, and March topics.

Dates for 2017 Season

Thursday January 12, 2017 Thursday February 9, 2017

Thursday March 9, 2017 Thursday April 13, 2017

All schools must complete the April exam and mail in the results by April 28th, 2017

New Jersey Science League

PO Box 65 Stewartsville, NJ 08886-0065

phone # 908-213-8923 fax # 908-213-9391 email: **newjsl@ptd.net**

Web address: **http://entnet.com/~personal/njscil/html/**

What is to be mailed back to our office?

PLEASE RETURN THE AREA RECORD AND ALL TEAM MEMBER SCANTRONS (ALL STUDENTS PLACING 1ST, 2ND, 3RD, AND 4TH).

If you return scantrons of alternates, then label them as ALTERNATES.

Dates 2018 Season

Thursday January 11, 2018 Thursday February 8, 2018

Thursday March 8, 2018 Thursday April 12, 2018

MECHANICS

$v_x = v_{x0} + a_x t$

$x = x_0 + v_{x0}t + \frac{1}{2}a_x t^2$

$v_x^2 = v_{x0}^{\ 2} + 2a_x(x - x_0)$

$\vec{a} = \frac{\sum \vec{F}}{m} = \frac{\vec{F}_{net}}{m}$

$\vec{F} = \frac{d\vec{p}}{dt}$

$\vec{J} = \int \vec{F}\, dt = \Delta\vec{p}$

$\vec{p} = m\vec{v}$

$|\vec{F}_f| \le \mu |\vec{F}_N|$

$\Delta E = W = \int \vec{F} \cdot d\vec{r}$

$K = \frac{1}{2}mv^2$

$P = \frac{dE}{dt}$

$P = \vec{F} \cdot \vec{v}$

$\Delta U_g = mg\Delta h$

$a_c = \frac{v^2}{r} = \omega^2 r$

$\vec{\tau} = \vec{r} \times \vec{F}$

$\vec{\alpha} = \frac{\sum \vec{\tau}}{I} = \frac{\vec{\tau}_{net}}{I}$

$I = \int r^2 dm = \sum mr^2$

$x_{cm} = \frac{\sum m_i x_i}{\sum m_i}$

$v = r\omega$

$\vec{L} = \vec{r} \times \vec{p} = I\vec{\omega}$

$K = \frac{1}{2}I\omega^2$

$\omega = \omega_0 + \alpha t$

$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$

a = acceleration
E = energy
F = force
f = frequency
h = height
I = rotational inertia
J = impulse
K = kinetic energy
k = spring constant
ℓ = length
L = angular momentum
m = mass
P = power
p = momentum
r = radius or distance
T = period
t = time
U = potential energy
v = velocity or speed
W = work done on a system
x = position
μ = coefficient of friction
θ = angle
τ = torque
ω = angular speed
α = angular acceleration
ϕ = phase angle

$\vec{F}_s = -k\Delta\vec{x}$

$U_s = \frac{1}{2}k(\Delta x)^2$

$x = x_{\max}\cos(\omega t + \phi)$

$T = \frac{2\pi}{\omega} = \frac{1}{f}$

$T_s = 2\pi\sqrt{\frac{m}{k}}$

$T_p = 2\pi\sqrt{\frac{\ell}{g}}$

$|\vec{F}_G| = \frac{Gm_1m_2}{r^2}$

$U_G = -\frac{Gm_1m_2}{r}$

ELECTRICITY AND MAGNETISM

$|\vec{F}_E| = \frac{1}{4\pi\varepsilon_0}\left|\frac{q_1q_2}{r^2}\right|$

$\vec{E} = \frac{\vec{F}_E}{q}$

$\oint \vec{E} \cdot d\vec{A} = \frac{Q}{\varepsilon_0}$

$E_x = -\frac{dV}{dx}$

$\Delta V = -\int \vec{E} \cdot d\vec{r}$

$V = \frac{1}{4\pi\varepsilon_0}\sum_i \frac{q_i}{r_i}$

$U_E = qV = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r}$

$\Delta V = \frac{Q}{C}$

$C = \frac{\kappa\varepsilon_0 A}{d}$

$C_p = \sum_i C_i$

$\frac{1}{C_s} = \sum_i \frac{1}{C_i}$

$I = \frac{dQ}{dt}$

$U_C = \frac{1}{2}Q\Delta V = \frac{1}{2}C(\Delta V)^2$

$R = \frac{\rho\ell}{A}$

$\vec{E} = \rho\vec{J}$

$I = Nev_d A$

$I = \frac{\Delta V}{R}$

$R_s = \sum_i R_i$

$\frac{1}{R_p} = \sum_i \frac{1}{R_i}$

$P = I\Delta V$

A = area
B = magnetic field
C = capacitance
d = distance
E = electric field
$\mathcal{E}$ = emf
F = force
I = current
J = current density
L = inductance
ℓ = length
n = number of loops of wire per unit length
N = number of charge carriers per unit volume
P = power
Q = charge
q = point charge
R = resistance
r = radius or distance
t = time
U = potential or stored energy
V = electric potential
v = velocity or speed
ρ = resistivity
Φ = flux
κ = dielectric constant

$\vec{F}_M = q\vec{v} \times \vec{B}$

$\oint \vec{B} \cdot d\vec{\ell} = \mu_0 I$

$d\vec{B} = \frac{\mu_0}{4\pi}\frac{I\, d\vec{\ell} \times \hat{r}}{r^2}$

$\vec{F} = \int I\, d\vec{\ell} \times \vec{B}$

$B_s = \mu_0 nI$

$\Phi_B = \int \vec{B} \cdot d\vec{A}$

$\mathcal{E} = \oint \vec{E} \cdot d\vec{\ell} = -\frac{d\Phi_B}{dt}$

$\mathcal{E} = -L\frac{dI}{dt}$

$U_L = \frac{1}{2}LI^2$

GEOMETRY AND TRIGONOMETRY

Rectangle

$A = bh$

Triangle

$A = \frac{1}{2}bh$

Circle

$A = \pi r^2$

$C = 2\pi r$

$s = r\theta$

Rectangular Solid

$V = \ell wh$

Cylinder

$V = \pi r^2 \ell$

$S = 2\pi r\ell + 2\pi r^2$

Sphere

$V = \frac{4}{3}\pi r^3$

$S = 4\pi r^2$

Right Triangle

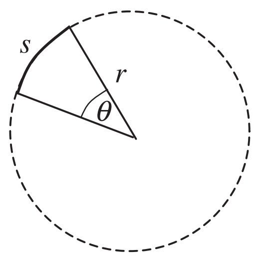
$a^2 + b^2 = c^2$

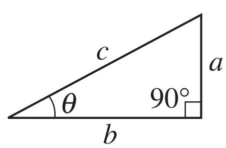
$\sin\theta = \frac{a}{c}$

$\cos\theta = \frac{b}{c}$

$\tan\theta = \frac{a}{b}$

A = area
C = circumference
V = volume
S = surface area
b = base
h = height
ℓ = length
w = width
r = radius
s = arc length
θ = angle





CALCULUS

$$\frac{df}{dx} = \frac{df}{du}\frac{du}{dx}$$

$$\frac{d}{dx}\left(x^n\right) = nx^{n-1}$$

$$\frac{d}{dx}\left(e^{ax}\right) = ae^{ax}$$

$$\frac{d}{dx}(\ln ax) = \frac{1}{x}$$

$$\frac{d}{dx}[\sin(ax)] = a\cos(ax)$$

$$\frac{d}{dx}[\cos(ax)] = -a\sin(ax)$$

$$\int x^n\,dx = \frac{1}{n+1}x^{n+1},\ n \neq -1$$

$$\int e^{ax}\,dx = \frac{1}{a}e^{ax}$$

$$\int \frac{dx}{x+a} = \ln|x+a|$$

$$\int \cos(ax)\,dx = \frac{1}{a}\sin(ax)$$

$$\int \sin(ax)\,dx = -\frac{1}{a}\cos(ax)$$

VECTOR PRODUCTS

$$\vec{A}\bullet\vec{B} = AB\cos\theta$$

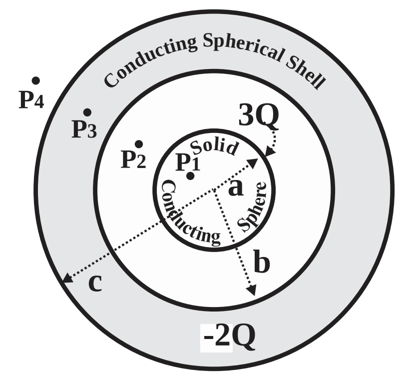
$$\left|\vec{A}\times\vec{B}\right| = AB\sin\theta$$

Physics C Science League Test Orchid **Correction: #11 all full credit**

March 9, 2017

DIRECTIONS: Please PRINT your name, school, area, and which test you are taking on the Scantron. 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. Sketches are not to scale.

Questions 1-7 refer to the diagram to the right which consists of a solid spherical conductor with a radius a and a charge of +3Q surrounded by a conducting spherical shell which has an inner radius b, an outer radius c and which contains a net charge -2Q. Assume that electric potential is zero at infinity.



1. Which of the following expressions gives the magnitude of the electric field **E** at point P_4?

   A. $E = \frac{kQ}{r^2}$ B. $E = \frac{-2kQ}{r^2}$ C. $E = \frac{5kQ}{r^2}$

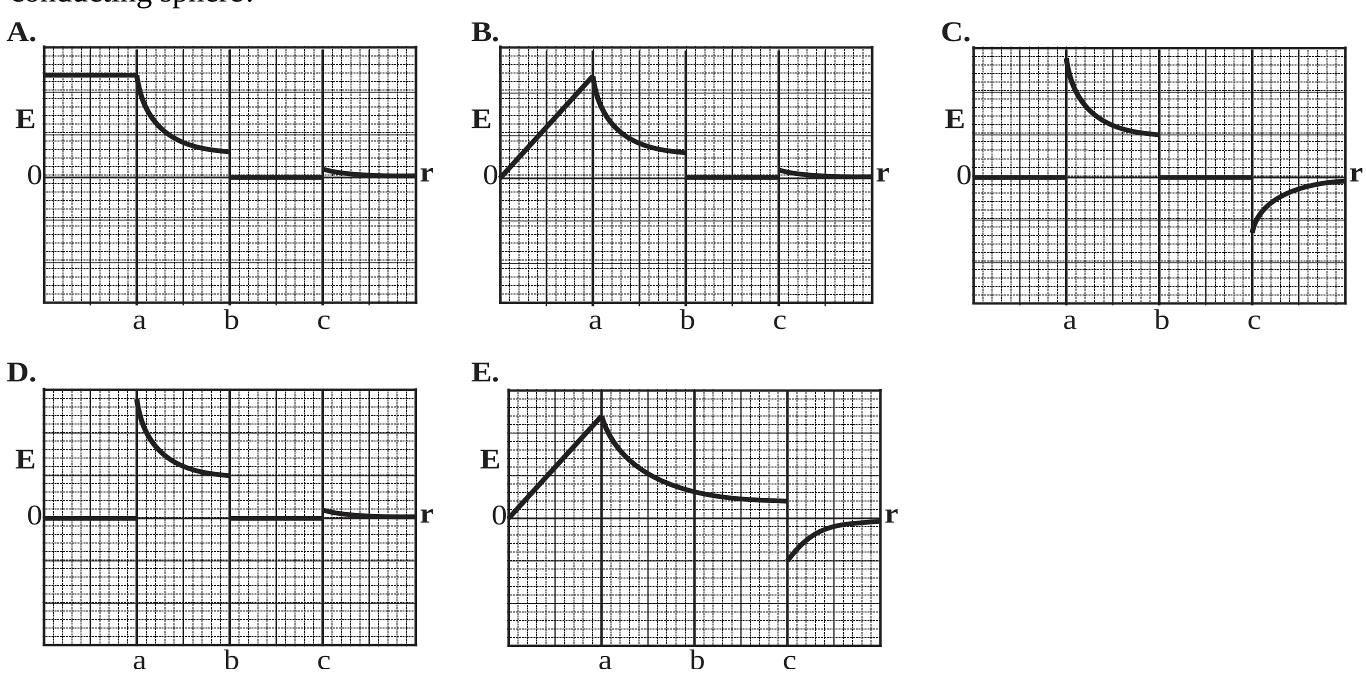
   D. $E = \frac{3kQ}{r^2}$ E. $E = 0$

2. Which of the following expressions gives the magnitude of the electric field **E** at point P_3?

   A. $E = \frac{kQ}{r^2}$ B. $E = \frac{-2kQ}{r^2}$ C. $E = \frac{5kQ}{r^2}$

   D. $E = \frac{3kQ}{r^2}$ E. $E = 0$

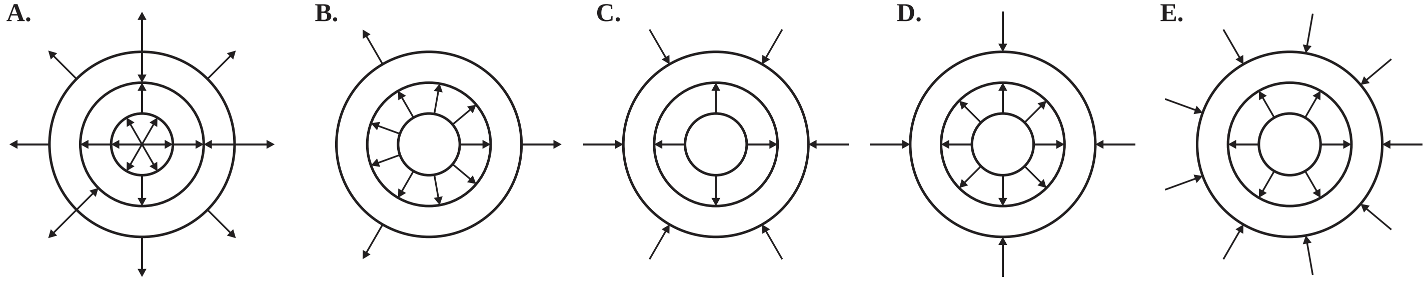
3. Which of the following graphs best plots the electric field as a function of distance from the center of the solid conducting sphere?



4. What will be the charge density **σ** on the outer surface of the outer conducting shell?

   A. $\sigma = \frac{Q}{4\pi c^2}$ B. $\sigma = \frac{3Q}{4\pi b^2}$ C. $\sigma = \frac{-3Q}{4\pi c^2}$ D. $\sigma = \frac{2Q}{4\pi c^2}$ E. $\sigma = \frac{-2Q}{4\pi c^2}$

5. Which of the following diagrams best describes the electric field generated by these two charged conductors



6. Which of the following expressions gives the potential difference between the outer surface of the inner sphere and the inner surface of the outer shell?

A. $V = \frac{kQ}{ab}(b-a)$ B. $V = \frac{3kQ}{b} - \frac{kQ}{a}$ C. $V = \frac{3kQ}{ab}(b-a)$

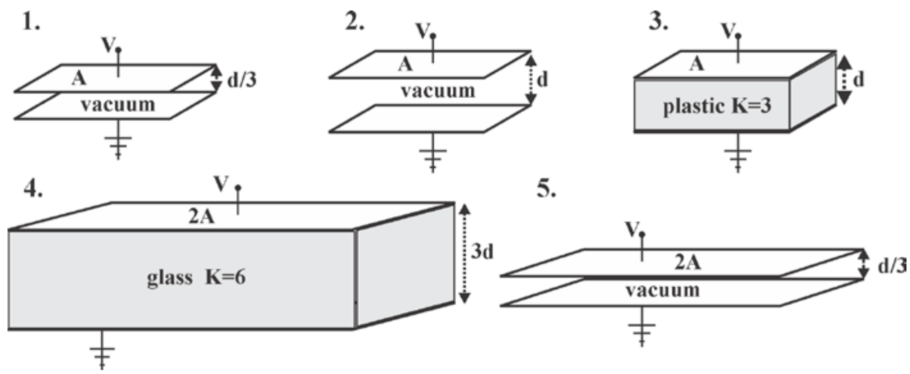
D. $V = \frac{5kQ}{a} - \frac{3kQ}{b}$ E. $V = \frac{3kQ}{a} - \frac{2kQ}{b}$

7. Which of the following expressions gives the magnitude of the electric potential at point P_1?

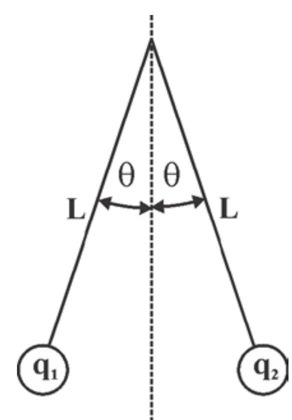
A. $V = \frac{5kQ}{c} - \frac{3kQ}{b-a}$ B. $V = kQ\left(\frac{1}{c} + \frac{3}{a} - \frac{3}{b}\right)$ C. $V = \frac{kQ}{c} - \frac{3kQ}{b-a}$

D. $V = \frac{3kQ}{c} - \frac{kQ}{b-a}$ E. $V = 3kQ\left(\frac{1}{c} - \frac{3}{a} + \frac{3}{b}\right)$

8. Rank the parallel plates capacitors to the right, which have areas A, distance between the plates d and dielectric insulators K as given, in order from least to greatest capacitance.
A. $1 \rightarrow 2 \rightarrow 3 = 4 \rightarrow 5$
B. $2 \rightarrow 1 = 3 \rightarrow 4 \rightarrow 5$
C. $4 \rightarrow 3 \rightarrow 5 = 2 \rightarrow 1$
D. $1 \rightarrow 2 = 4 \rightarrow 3 \rightarrow 5$
E. $3 \rightarrow 5 \rightarrow 2 \rightarrow 4 \rightarrow 1$



Two conducting foam balls, each with a mass of 3.00 gm. and a radius of 2.50 cm., are attached to the ends of two insulating strings each with a length of L = 50.0 cm. A rubber rod is rubbed with fur and is then touched to the two balls transferring charge to the two balls equally. The two balls then repel each other until the angle between each string and the vertical becomes θ = 4.00 degrees.



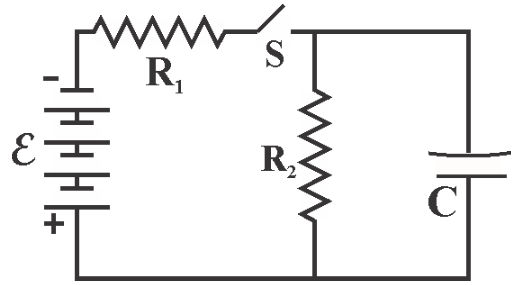
9. What will be the magnitude of the electric force between these two balls?
A. 8.04×10^{-3}N B. 2.06×10^{-3}N C. 4.02×10^{-3}N
D. 1.15×10^{-2}N E. 3.30×10^{-2}N

10. What will be the net charge on each ball?
A. -0.175 μC B. -0.66 μC C. 0.0175 μC D. -0.035 μC E. 0.220 μC

11. How many electrons were transferred from or to the rubber rod to charge both of these two balls? All full credit key has Problem is corrected charge of electron left off.
A. 4.38×10^{11} electrons from the rod B. 2.19×10^{11} electrons to the rod
C. 2.19×10^{11} electrons from the rod D. 1.44×10^{12} electrons to the rod

E. 2.88 x 10^{12} electrons to the rod

A capacitor C = 1000 μF is connected as shown in the diagram to the right with two resistors, R_1 = 10,000 Ω and R_2 = 5000 Ω, a source of EMF $\mathcal{E}$ = 18.0 Volts and a switch S which is initially in the open position as shown.



12. What will be the current I_o in this circuit immediately after the switch **S** is closed?
    A. 1.20 mA B. 0.0 mA C. 3.60 mA
    D. 1.80 mA E. 0.60 mA

13. What will be the current I_f flowing in this circuit a long time after the switch **S** has been closed?
    A. 1.20 mA B. 0.0 mA C. 3.60 mA D. 1.80 mA E. 0.60 mA

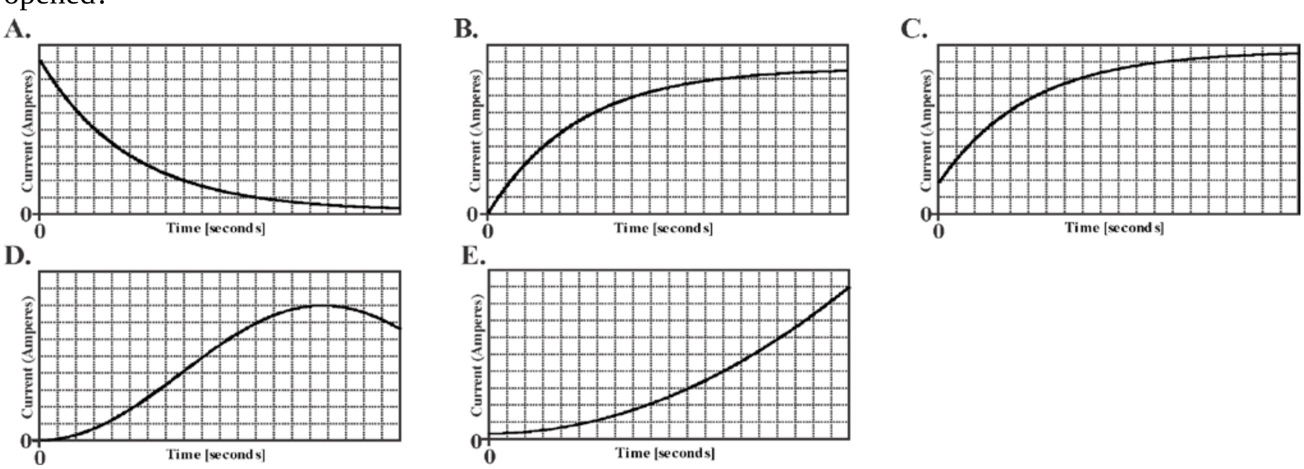
14. What will be the potential difference across the capacitor a long time after the switch S has been closed?
    A. 18.0 Volt B. 6.0 Volt C. 4.0 Volt D. 3.0 Volt E. 12.0 Volt

15. How much charge will be stored on either plate of the capacitor a long time after the switch S has been closed?
    A. 6000 μC B. 2000 μC C. 1200 μC D. 1800 μC E. 300 μC

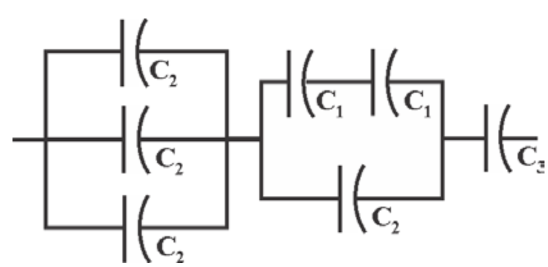
After the switch S has been closed for a long time, the switch is then reopened.

16. How much charge will remain on either plate of the capacitor after the switch has been opened for t = 10.0 s?
    A. 600 μC B. 3000 μC C. 150 μC D. 812 μC E. 0.20 μC

17. Which of the following graphs best represents the current through the resistor R_2 after the switch S has been opened?



18. Consider the network of capacitors at the right where C_1 = 8.0 μF, C_2 = 2.0 μF and C_3 = 6 μF. What is the equivalent capacitance of this network?
    A. 1.0 μF B. 12.0 μF C. 8.0 μF
    D. 6.0 μF E. 2.0 μF

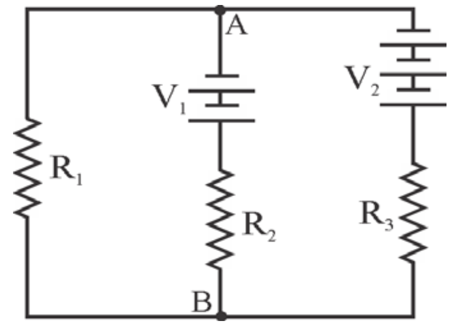


19. A glass rod is rubbed with silk. The glass rod will ___.
    A. gain protons from the silk becoming positively charged.
    B. gain electrons from the silk becoming negatively charged.
    C. lose electrons to the silk becoming positively charged.
    D. gain electrons from the silk becoming positively charged.
    E. lose electrons to the silk becoming negatively charged.

The elements of the circuit to the right have the following values:

$R_1 = 100\ \Omega$ $R_2 = 200\ \Omega$ $R_3 = 300\ \Omega$

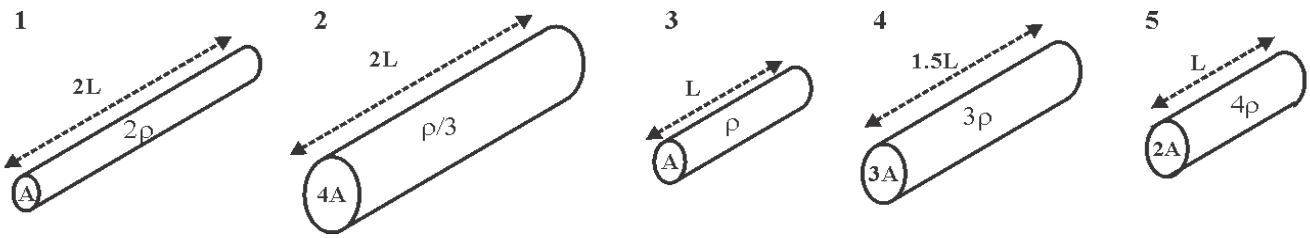
$V_2 = 20.0$ Volts $V_1 = 8.0$ Volts



20. What will be the magnitude of the current flowing through resistor R_2?
A. 0.011 A B. 0.032 A C. 0.058 A
D. 0.047 A E. 0.024A

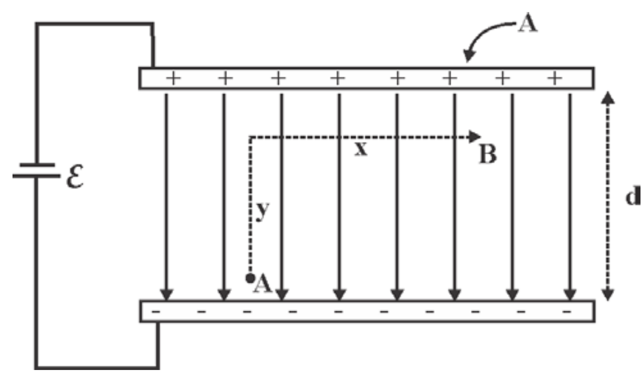
21. What will be the reading on a voltmeter connected between points A and B?
A. 5.8 V B. 4.2 V C. 12.0 V D. 9.2 V E. 10.2 V

22. Rank the wires below in terms of their relative resistances from least to most resistance.



A. 1 → 2 → 3 = 4 → 5 B. 2 → 1 = 3 → 4 → 5 C. 2 → 3 → 4 → 5 → 1
D. 1 → 2 = 4 → 3 → 5 E. 3 → 5 → 2 → 4 → 1

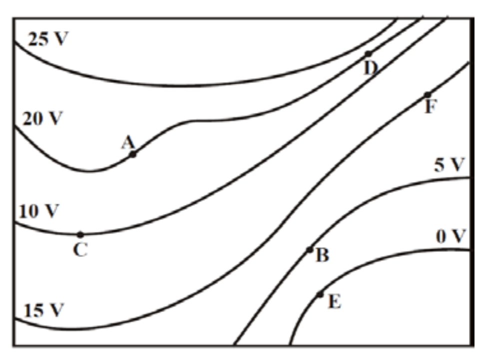
Two parallel plates, each with an area A, are separated by a distance d. These plates are then connected together with a battery which has an emf $\mathcal{E}$. In terms of the given quantities and any appropriate fundamental constants:



23. How much work will be done in moving a charge **q** from point **A** to point **B** in this electric field.
A. $\frac{\mathcal{E}qy}{d}$ B. $\frac{\mathcal{E}q\sqrt{x^2+y^2}}{d}$ C. $\frac{\mathcal{E}qyx}{d^2}$
D. $\frac{\mathcal{E}qx}{y}$ E. $\frac{\mathcal{E}qy}{\sqrt{d^2+x^2}}$

24. What will be the magnitude of the charge density **σ** on each of the parallel plates?
A. $\frac{\varepsilon_o A}{d}$ B. $\frac{\varepsilon_o A\mathcal{E}}{d}$ C. $\frac{\mathcal{E}A}{d}$ D. $\frac{\varepsilon_o}{d}\mathcal{E}$ E. $\frac{\varepsilon_o A}{d^2}$

The equipotential diagram shown at the right is of an electric field caused by an unknown distribution of static charges.



25. At which of the labeled points in this electric field is the magnitude of the electric field the greatest?
A. A B. B C. C D. D E. E

ADVANCED PLACEMENT PHYSICS C EQUATIONS

updated 2-20-2017

MECHANICS

$v_x = v_{x0} + a_x t$

$x = x_0 + v_{x0} t + \frac{1}{2} a_x t^2$

$v_x^2 = v_{x0}^2 + 2a_x(x - x_0)$

$\vec{a} = \frac{\sum \vec{F}}{m} = \frac{\vec{F}_{net}}{m}$

$\vec{F} = \frac{d\vec{p}}{dt}$

$\vec{J} = \int \vec{F}\,dt = \Delta\vec{p}$

$\vec{p} = m\vec{v}$

$|\vec{F}_f| \le \mu |\vec{F}_N|$

$\Delta E = W = \int \vec{F} \cdot d\vec{r}$

$K = \frac{1}{2}mv^2$

$P = \frac{dE}{dt}$

$P = \vec{F} \cdot \vec{v}$

$\Delta U_g = mg\Delta h$

$a_c = \frac{v^2}{r} = \omega^2 r$

$\vec{\tau} = \vec{r} \times \vec{F}$

$\vec{\alpha} = \frac{\sum \vec{\tau}}{I} = \frac{\vec{\tau}_{net}}{I}$

$I = \int r^2 dm = \sum mr^2$

$x_{cm} = \frac{\sum m_i x_i}{\sum m_i}$

$v = r\omega$

$\vec{L} = \vec{r} \times \vec{p} = I\vec{\omega}$

$K = \frac{1}{2}I\omega^2$

$\omega = \omega_0 + \alpha t$

$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$

a = acceleration
E = energy
F = force
f = frequency
h = height
I = rotational inertia
J = impulse
K = kinetic energy
k = spring constant
ℓ = length
L = angular momentum
m = mass
P = power
p = momentum
r = radius or distance
T = period
t = time
U = potential energy
v = velocity or speed
W = work done on a system
x = position
μ = coefficient of friction
θ = angle
τ = torque
ω = angular speed
α = angular acceleration
ϕ = phase angle

$\vec{F}_s = -k\Delta\vec{x}$

$U_s = \frac{1}{2}k(\Delta x)^2$

$x = x_{\max}\cos(\omega t + \phi)$

$T = \frac{2\pi}{\omega} = \frac{1}{f}$

$T_s = 2\pi\sqrt{\frac{m}{k}}$

$T_p = 2\pi\sqrt{\frac{\ell}{g}}$

$|\vec{F}_G| = \frac{Gm_1 m_2}{r^2}$

$U_G = -\frac{Gm_1 m_2}{r}$

ELECTRICITY AND MAGNETISM

$|\vec{F}_E| = \frac{1}{4\pi\varepsilon_0}\left|\frac{q_1 q_2}{r^2}\right|$

$\vec{E} = \frac{\vec{F}_E}{q}$

$\oint \vec{E} \cdot d\vec{A} = \frac{Q}{\varepsilon_0}$

$E_x = -\frac{dV}{dx}$

$\Delta V = -\int \vec{E} \cdot d\vec{r}$

$V = \frac{1}{4\pi\varepsilon_0}\sum_i \frac{q_i}{r_i}$

$U_E = qV = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r}$

$\Delta V = \frac{Q}{C}$

$C = \frac{\kappa\varepsilon_0 A}{d}$

$C_p = \sum_i C_i$

$\frac{1}{C_s} = \sum_i \frac{1}{C_i}$

$I = \frac{dQ}{dt}$

$U_C = \frac{1}{2}Q\Delta V = \frac{1}{2}C(\Delta V)^2$

$R = \frac{\rho\ell}{A}$

$\vec{E} = \rho\vec{J}$

$I = Nev_d A$

$I = \frac{\Delta V}{R}$

$R_s = \sum_i R_i$

$\frac{1}{R_p} = \sum_i \frac{1}{R_i}$

$P = I\Delta V$

A = area
B = magnetic field
C = capacitance
d = distance
E = electric field
$\mathcal{E}$ = emf
F = force
I = current
J = current density
L = inductance
ℓ = length
n = number of loops of wire per unit length
N = number of charge carriers per unit volume
P = power
Q = charge
q = point charge
R = resistance
r = radius or distance
t = time
U = potential or stored energy
V = electric potential
v = velocity or speed
ρ = resistivity
Φ = flux
κ = dielectric constant

$\vec{F}_M = q\vec{v} \times \vec{B}$

$\oint \vec{B} \cdot d\vec{\ell} = \mu_0 I$

$d\vec{B} = \frac{\mu_0}{4\pi}\frac{I\,d\vec{\ell} \times \hat{r}}{r^2}$

$\vec{F} = \int I\,d\vec{\ell} \times \vec{B}$

$B_s = \mu_0 nI$

$\Phi_B = \int \vec{B} \cdot d\vec{A}$

$\mathcal{E} = \oint \vec{E} \cdot d\vec{\ell} = -\frac{d\Phi_B}{dt}$

$\mathcal{E} = -L\frac{dI}{dt}$

$U_L = \frac{1}{2}LI^2$

GEOMETRY AND TRIGONOMETRY

Rectangle

$A = bh$

Triangle

$A = \frac{1}{2}bh$

Circle

$A = \pi r^2$

$C = 2\pi r$

$s = r\theta$

Rectangular Solid

$V = \ell wh$

Cylinder

$V = \pi r^2 \ell$

$S = 2\pi r\ell + 2\pi r^2$

Sphere

$V = \frac{4}{3}\pi r^3$

$S = 4\pi r^2$

Right Triangle

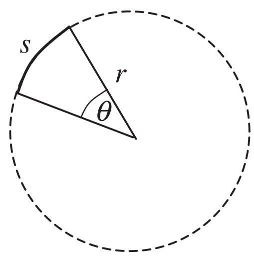
$a^2 + b^2 = c^2$

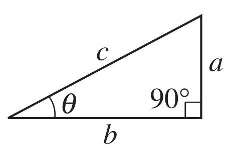
$\sin\theta = \frac{a}{c}$

$\cos\theta = \frac{b}{c}$

$\tan\theta = \frac{a}{b}$

A = area
C = circumference
V = volume
S = surface area
b = base
h = height
ℓ = length
w = width
r = radius
s = arc length
θ = angle





CALCULUS

$$\frac{df}{dx} = \frac{df}{du}\frac{du}{dx}$$

$$\frac{d}{dx}\left(x^n\right) = nx^{n-1}$$

$$\frac{d}{dx}\left(e^{ax}\right) = ae^{ax}$$

$$\frac{d}{dx}(\ln ax) = \frac{1}{x}$$

$$\frac{d}{dx}[\sin(ax)] = a\cos(ax)$$

$$\frac{d}{dx}[\cos(ax)] = -a\sin(ax)$$

$$\int x^n\,dx = \frac{1}{n+1}x^{n+1},\ n \neq -1$$

$$\int e^{ax}\,dx = \frac{1}{a}e^{ax}$$

$$\int \frac{dx}{x+a} = \ln|x+a|$$

$$\int \cos(ax)\,dx = \frac{1}{a}\sin(ax)$$

$$\int \sin(ax)\,dx = -\frac{1}{a}\cos(ax)$$

VECTOR PRODUCTS

$$\vec{A}\bullet\vec{B} = AB\cos\theta$$

$$\left|\vec{A}\times\vec{B}\right| = AB\sin\theta$$

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

Date March 9, 2017

Solutions

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

JANUARY: kinematics in one and two dimensions; Newton's laws including resistance forces and dynamics of circular motion; vector algebra (mostly assumed as needed); energy and its conservation including potential energy and conservative forces, momentum and its conservation including two-dimensional situations
FEBRUARY: angular mechanics including rotational equilibrium, rotational dynamics, rotational energy, and angular momentum; oscillatory motion including kinematics, dynamics, energy, and damping; gravitation including kinematics and dynamics of planetary motion, angular momentum, and energy as applied to gravitation. <u>Plus Jan topics</u>
MARCH: electrostatics including electrostatic forces, electrostatic field, electrostatic field flux and Gauss's Law; electrostatic potential and potential energy; dc electrical circuits including multi-loop circuits and power; capacitors, dielectrics, and circuits with capacitors. <u>Plus Jan and Feb Topics</u>.
APRIL: Magnetic Fields and Forces including the applications of the Lorenz force, the Law of Biot-Savart, Ampere's Law, magnetic field flux and Faraday's Law, Lenz's Law for electromagnetic induction; magnetic materials, applications of electromagnetic induction, and circuits with inductors. <u>Plus Jan, Feb, and March topics.</u>

Dates for 2017 Season
Thursday March 9, 2017   Thursday April 13, 2017
All schools must complete the April exam and mail in the results by April 28th, 2017

New Jersey Science League
PO Box 65 Stewartsville, NJ 08886-0065
phone # 908-213-8923 fax # 908-213-9391 email: **newjsl@ptd.net**
Web address: **http://entnet.com/~personal/njscil/html/**

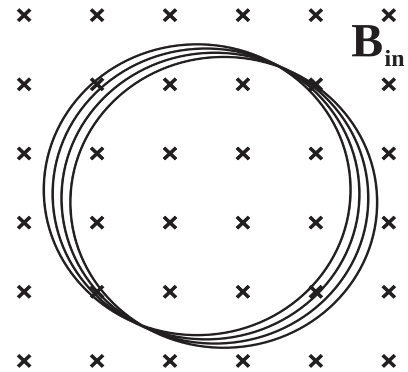
What is to be mailed back to our office?
PLEASE RETURN THE AREA RECORD AND ALL TEAM MEMBER SCANTRONS (ALL STUDENTS PLACING 1ST, 2ND, 3RD, AND 4TH).
If you return scantrons of alternates, then label them as ALTERNATES.

Dates 2018 Season
Thursday January 11, 2018   Thursday February 8, 2018
Thursday March 8, 2018   Thursday April 12, 2018

Physics C Science League Test Orchid
April , 2017 **No corrections**

$\mu_o = 4{\cdot}\pi \times 10^{-7}$ N/A^2 $k_m = \mu_o/(4{\cdot}\pi) = 10^{-7}$ N/A^2 10^4 Gauss = 1 Tesla $e = 1.6 \times 10^{-19}$ C

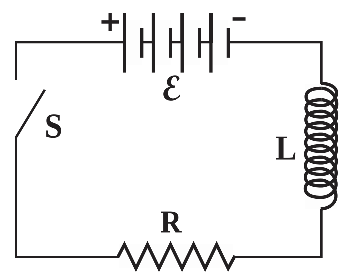
A coil of wire, which has a radius of 5.5 cm, a resistance of 1.6 Ω and which consists of 40 turns, is sitting in a uniform magnetic field directed into the page as shown on the right. The magnetic field B_{in} is increasing from an initial value of 0.20 Teslas at the rate of 0.40 Teslas/second.



1. What will be the magnitude and direction of the resulting current flowing in the coil?
   A. 0.095 amp, CCW B. 0.038 amp, CCW C. 0.380 amp, CW
   D. 0.128 amp, CW E. 0.0128 amp, CCW

2. According to one of Maxwell's equations $\oint B \cdot dA = 0$.
   Based on this equation, one can conclude that _________ .
   A. the net magnetic flux through a closed surface depends on the current inside
   B. the net magnetic flux through a closed surface depends on the charge inside
   C. magnetic flux is always conserved
   D. magnetic flux through a closed surface increases as time passes
   E. magnetic monopoles do not exist

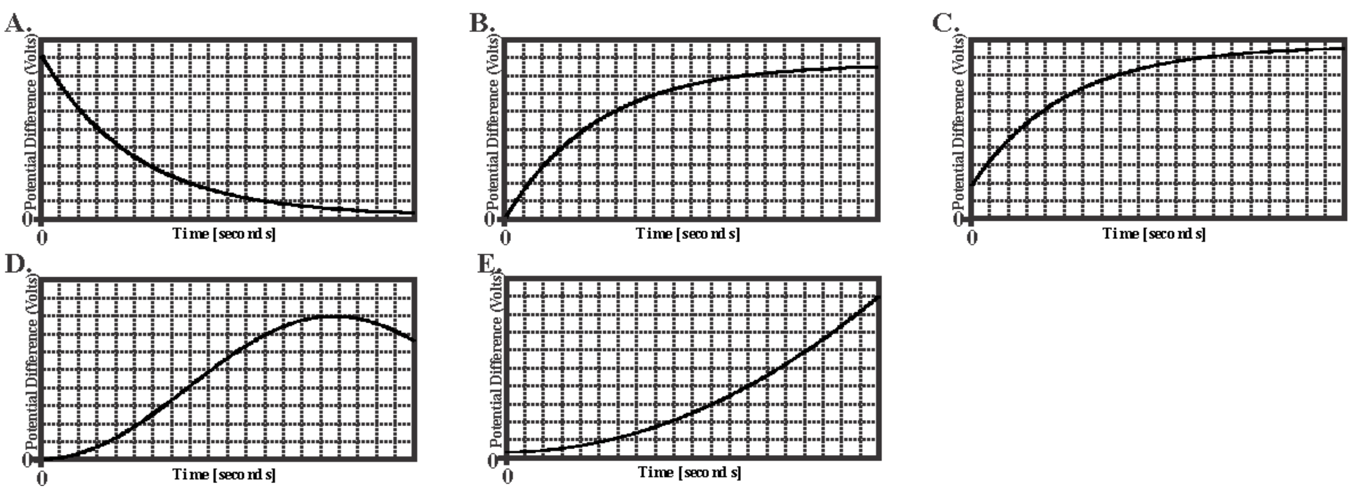
Questions 3-6 refer to the circuit at the right that consists of a source of EMF $\mathcal{E}$ = 12.0 Volts, a resistor R = 2.0 Ω and an inductor L = 10.0 H. At t = 0s the switch S is closed.



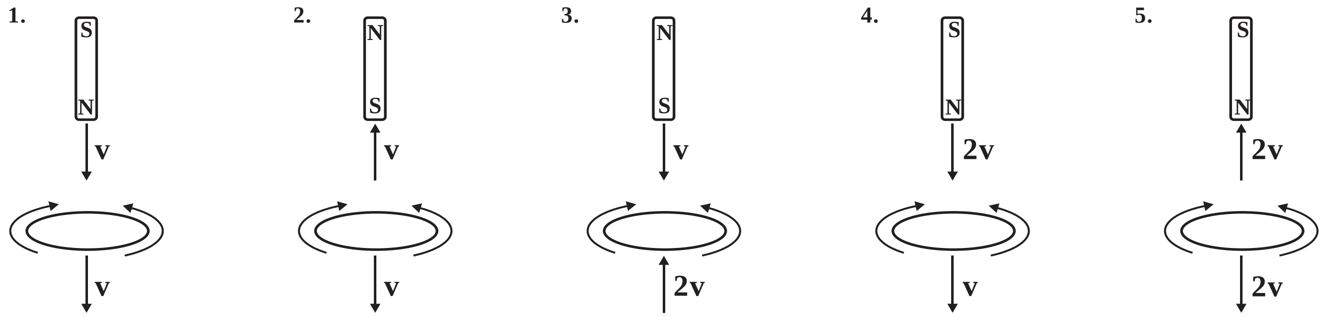
3. What will be the current through resistor **R** immediately after the switch **S** has been closed?
   A. 0.0 A B. 1.2 A C. 3.8 A D. 4.8 A E. 6.0 A

4. What will be the current through resistor **R**, exactly one time constant t_c after the switch **S** has been closed?
   A. 0.0 A B. 1.2 A C. 3.8 A D. 4.8 A E. 6.0 A

5. Which of the following graphs BEST plots the potential difference across the inductor as a function of time?

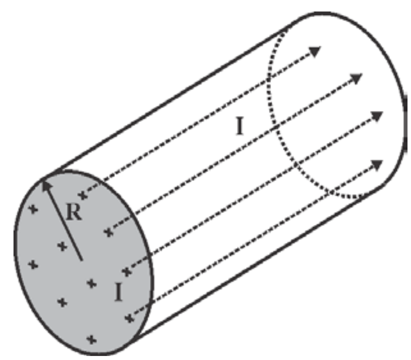


6. A loop of wire with a resistance **R** and a permanent magnet are each moving as shown in the diagrams below. Rank each of these systems in order from greatest to least magnitude current.



A. 1 → 3 → 4 → 5 → 2 B. 5 → 3 → 2 → 4 → 1 C. 3 → 4 → 1 → 2 → 5
D. 1 → 4 = 3 → 2 →5 E. 5 → 1 → 3 = 4 → 2

Questions 7-8: A current I is flowing uniformly through a conducting wire, which has a radius R, as shown to the right.

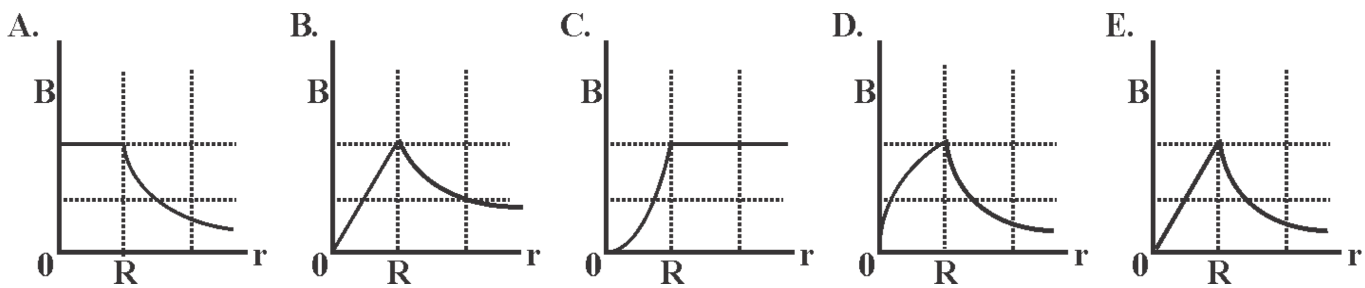


7. What will be the strength of the magnetic field **B** as a function of distance from the center of the wire for r < R?

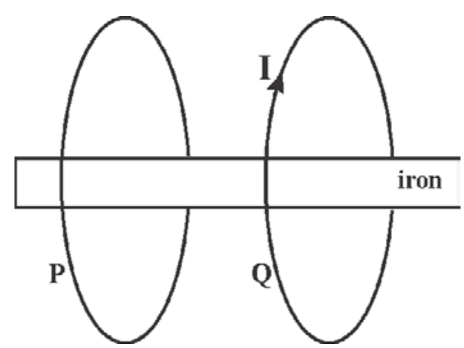
A. $B = \frac{\mu_o I}{2r}$ B. $B = \frac{\mu_o I}{2\pi}$ C. $B = \frac{\mu_o I}{2\pi R}$

D. $B = \frac{\mu_o I r}{2\pi R^2}$ E. $B = \frac{\mu_o I R}{2\pi r}$

8. Which of the following graphs best shows the magnetic field as a function of distance **r** from the center of the conducting wire?

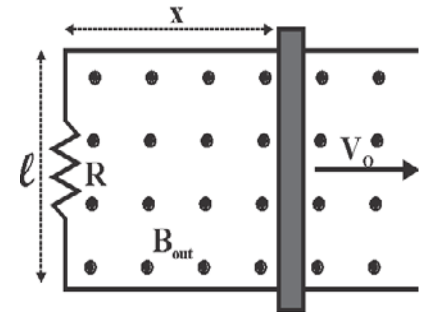


9. Two circular loops of conducting wire, P and Q, surround an iron bar as shown to the right. Loop Q has a current I flowing clockwise that is increasing as a function of time. Which of the following statements correctly describes what will happen as a result of this increasing current?



A. A clockwise current will be generated in loop **P**.
B. Nothing will happen since there is no current flowing in loop **P**.
C. An electric force will act on loop P tending to cause it to expand.
D. The two loops will repel one another.
E. Loop **P** will feel a torque causing it to rotate clockwise about the bar magnet.

Questions 10-13: A conducting rod, which has a mass of M, is free to move on a pair of horizontal, frictionless rails which are spaced a distance ℓ apart. The rails are connected together at one end with a resistor R so that a complete circuit is formed. There is a uniform magnetic field of B oriented perpendicularly out of the plane of the paper as shown. The rod and rails have negligible resistance. At time t = 0, the rod is moving to the right with a velocity v_o and is then released.



10. At what rate is energy being dissipated in the resistor **R** when t = 0s?

A. $B^2\cdot\ell\cdot v_o/R^2$ B. $B^2\cdot\ell^2\cdot v_o^2/R$ C. $B\cdot\ell^2\cdot v_o/R$ D. $B^2\cdot\ell^2\cdot v_o/R^2$ E. $B^2\cdot\ell^2\cdot v_o^2/R^2$

11. Which of the following expressions describes the velocity of the conducting rod as a function of time?

A. $v = v_o \cdot e^{-\frac{B^2 l^2}{R\cdot M}t}$ B. $v = v_o \cdot \left(1 - e^{-\frac{B^2 l^2}{R\cdot M}t}\right)$ C. $v = v_o \cdot \left(1 - e^{-\frac{R\cdot M}{B^2 l^2}t}\right)$

D. $v = v_o \cdot e^{-\frac{B\cdot l^2}{R}t}$ E. $v = v_o \cdot \left(1 - e^{-\frac{B^2 l^2}{R\cdot M}t}\right)^2$

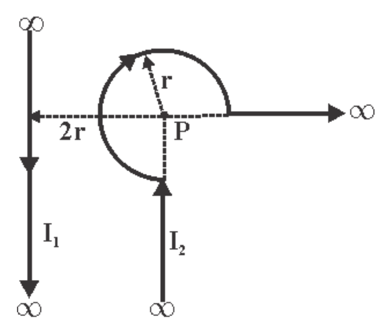
12. How far will this rod slide along the rails before coming to rest?

A. $\frac{v_o \cdot B^2}{R\cdot l}$ B. $\frac{v_o \cdot B^2}{R^2\cdot l}$ C. $\frac{v_o\cdot R\cdot M}{B^2\cdot l^2}$ D. $\frac{v_o\cdot R^2\cdot M}{B\cdot l^2}$ E. $\frac{v_o{}^2\cdot R^2\cdot M}{B\cdot l}$

13. How much energy will be dissipated in the resistance R from the time that the conducting rod is released and the rod finally comes to rest?

A. $\frac{B^2 l^2}{R\cdot M}\cdot t$ B. $\frac{R\cdot M}{B^2 l^2}t$ C. $\frac{R\cdot M}{B^2 l^2}v_o$ D. $\frac{1}{2}\cdot M\cdot v_o^2$ E. $\frac{R\cdot M}{B^2 l^2}v_o{}^2$

Questions 14-16: Two current carrying wires are as shown to the right. The straight portions of each wire extend off to infinity. Current I_1 = 20.0 A, current I_2 = 5.0 A, the radius of the circular section is r = 8.0 cm and the distance between the long, straight wire and the center of the circular section is 2r = 16.0 cm.



14. What will be the direction of the magnetic field at point P?

A. left B. right C. top of page D. out of page E. into page

15. What will be the magnitude of the magnetic field at point P due to the long straight wire?

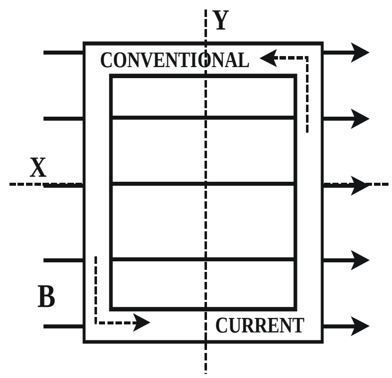
A. 1.5×10^{-5} Tesla B. 2.5×10^{-5} Tesla C. 4.45×10^{-6} Tesla
D. 4.0×10^{-6} Tesla E. 5.0×10^{-5} Tesla

16. What will be the magnitude of the net magnetic field at point P due to both wires?

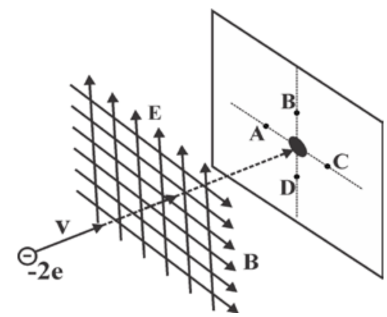
A. 1.5×10^{-5} Tesla B. 2.5×10^{-5} Tesla C. 4.45×10^{-6} Tesla
D. 4.0×10^{-6} Tesla E. 5.0×10^{-5} Tesla

17. The instantaneous induced EMF in a coil located in a magnetic field __________.
   A. is determined primarily by the resistance of the wire from which the coil is made
   B. is independent of the number of turns in the coil
   C. depends on the instantaneous value of the flux through the coil
   D. is inversely proportional to the cross sectional area of the coil
   E. depends on the time rate of change of the magnetic flux through the coil

18. A loop of wire is sitting in a magnetic field as shown to the right. Conventional current is flowing through this loop as shown. What will be the resulting effect on the loop?
   A. The loop will feel a clockwise torque about the X axis as viewed from the left.
   B. The loop will feel a clockwise torque about the Y axis as viewed from above.
   C. The loop will tend to compress inward.
   D. The loop will feel a counter-clockwise torque about the Y axis as viewed from above.
   E. The loop will feel no force at all.



Questions 19-21: A beam of negatively charged ions is fired into a region with crossed electric and magnetic fields as shown to the right. These ions pass through both fields undeflected and then pass through a hole in a metal plate. The magnetic field is B = 0.15 Tesla, the electric field is E = 4.5 x 10^4 N/C and the ions each have a charge -2e [e = 1.6 x 10^{-19}C] and a mass of m = 5.89 x 10^{-23} kg.



19. What is the speed of the ions as they pass through the hole?
   A. 4.5 x 10^6 m/s   B. 6.0 x 10^5 m/s   C. 2.0 x 10^5 m/s
   D. 6.0 x 10^6 m/s   E. 3.0 x 10^5 m/s

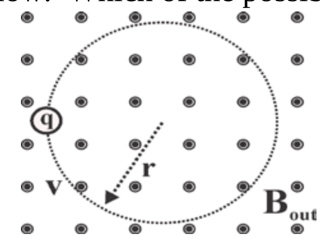
Suppose that the particles in the beam were +2e rather than -2e.

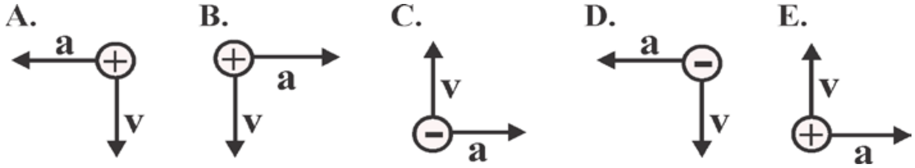
20. At which of the points labeled on the diagram will the ions now most closely strike the plate?
   A. A   B. B   C. C
   D. D   E. The beam will still pass through the hole in the plate.

Suppose, instead, that the speed of these negative ions is <u>less</u> than that determined above.

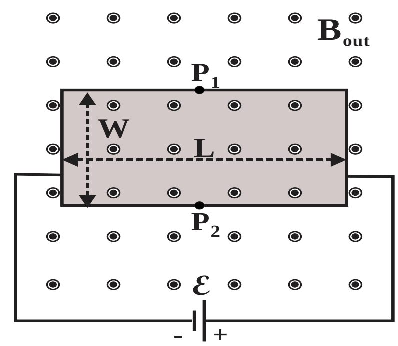
21. At which of the points labeled on the diagram will the ions now most closely strike the plate?
   A. A   B. B   C. C   D. D   E. The beam will still pass through the hole in the plate.

22. A charged particle is moving in a circular path in a magnetic field as shown below. Which of the possible combinations of charge, velocity and acceleration is consistent with the charged particle at the point in the circular path as shown?





A Hall Effect device consists of a very thin rectangular sheet of aluminum with a length L and width W. The long ends of the sheet are connected to an external EMF as shown, causing a conventional current to flow through the sheet.

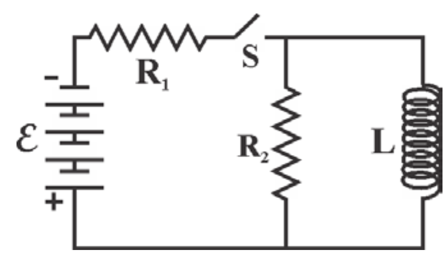


23. Which of the following statements is true?
   A. $\mathbf{P_1}$ is at a higher potential than $\mathbf{P_2}$.
   B. $\mathbf{P_1}$ is at a lower potential than $\mathbf{P_2}$.
   C. $\mathbf{P_1}$ and $\mathbf{P_2}$ are both at equal positive potential.
   D. $\mathbf{P_1}$ and $\mathbf{P_2}$ are both at equal negative potential.
   E. The potential difference generated by the Hall Effect causes the current to drop to zero.

24. Ferromagnetic materials are different from diamagnetic materials in that diamagnetic materials____________.
   A. are weakly attracted to a magnet while ferromagnetic materials are strongly attracted to a magnet
   B. are weakly repelled by a magnetic while ferromagnetic materials are strongly repelled by a magnet
   C. are strongly attracted to a magnet while ferromagnetic materials are weakly attracted to a magnet
   D. are weakly repelled by a magnet while ferromagnetic materials are strongly attracted to a magnet
   E. have many unpaired electrons while ferromagnetic materials have all of their electrons paired

In the circuit below switch S is closed until equilibrium has been reached. At this point, switch S is reopened.

25. How much energy will be dissipated in resistor $\mathbf{R_2}$ from the time that switch **S** is reopened until equilibrium is again reached?



A. $U = \frac{L\cdot\mathcal{E}^2}{2\cdot R_1{}^2}$ B. $U = \frac{L\cdot\mathcal{E}^3}{4\cdot R_1{}^2}$ C. $U = \frac{3\cdot L\cdot\mathcal{E}^2}{2\cdot R_2{}^2}$
D. $U = \frac{L\cdot\mathcal{E}^2}{(R_1+R_2)^2}$ E. $U = \frac{4\cdot L\cdot\mathcal{E}^2}{R_2{}^2}$

Physics C Answer Key: **Orchid Test**

Date April 2017 No Corrections

Solutions

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

JANUARY: kinematics in one and two dimensions; Newton's laws including resistance forces and dynamics of circular motion; vector algebra (mostly assumed as needed); energy and its conservation including potential energy and conservative forces, momentum and its conservation including two-dimensional situations
FEBRUARY: angular mechanics including rotational equilibrium, rotational dynamics, rotational energy, and angular momentum; oscillatory motion including kinematics, dynamics, energy, and damping; gravitation including kinematics and dynamics of planetary motion, angular momentum, and energy as applied to gravitation. Plus Jan topics
MARCH: electrostatics including electrostatic forces, electrostatic field, electrostatic field flux and Gauss's Law; electrostatic potential and potential energy; dc electrical circuits including multi-loop circuits and power; capacitors, dielectrics, and circuits with capacitors. Plus Jan and Feb Topics.
APRIL: Magnetic Fields and Forces including the applications of the Lorenz force, the Law of Biot-Savart, Ampere's Law, magnetic field flux and Faraday's Law, Lenz's Law for electromagnetic induction; magnetic materials, applications of electromagnetic induction, and circuits with inductors. Plus Jan, Feb, and March topics.

Dates for 2017 Season
Thursday April 13, 2017
All schools must complete the April exam and mail in the results by April 28th, 2017

New Jersey Science League
PO Box 65 Stewartsville, NJ 08886-0065
Cell phone # 908-213-8923 fax # 908-213-9391 email: **newjsl@ptd.net**
Web address: **http://entnet.com/~personal/njscil/html/**

What is to be mailed back to our office?
PLEASE RETURN THE AREA RECORD AND ALL TEAM MEMBER SCANTRONS (ALL STUDENTS PLACING 1ST, 2ND, 3RD, AND 4TH).
If you return scantrons of alternates, then label them as ALTERNATES.

Dates 2018 Season
Thursday January 11, 2018 Thursday February 8, 2018
Thursday March 8, 2018 Thursday April 12, 2018