NJSL Physics C Exam Orchid

January 11, 2018

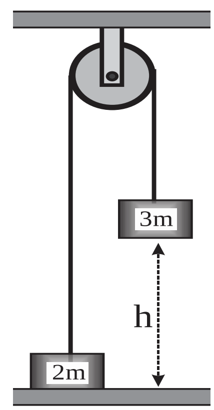
DIRECTIONS: Please PRINT your name, school, area, and which test you are taking on the Scantron. For each statement or question, completely fill in the appropriate space on the answer sheet. Use the letter preceding the word or phrase or sketch which best completes the statement or answers the question. Unless stated otherwise, assume ideal conditions including no friction with the air. Sketches are not to scale. Corrections

Assume g = 10. m/s^2

1. Two people are in a boat that is capable of a maximum speed of 8.0 m/s in still water, and wish to cross a river 1600 meters wide to a point directly across from the starting point. If the speed of the water in the river is 3.0 m/s, how much time is required for the crossing?
   A. 200 s B. 145 s C. 216 s D. 320 s E. 533 s

2. A rubber stopper is attached to a string and is swung in a horizontal circle overhead. As the stopper passes immediately in front of you, moving from right to left, the string breaks. What will be the direction of motion of the stopper immediately after the string breaks?
   A. The stopper will fall straight down to the floor.
   B. The stopper will move radially away from you and fall toward the floor.
   C. The stopper will initially curve toward your left finally falling diagonally to the floor.
   D. The stopper will move tangent to the circle and will follow a parabolic path toward the floor.
   E. The stopper will initially curve slightly toward your left, straighten out, and then fall to the floor.

3. A particle moves along the x axis with a non-constant acceleration described by a = 12 t + 6, where a is measured in meters/second squared and t is in seconds. If the particle has a velocity of 8.0 m/s and is located at 25 m when t = 5 s, where will the object be located when t = 12.0 seconds?
   A. 1440 m B. 1850 m C. 2380 m D. -320 m E. -1440 m

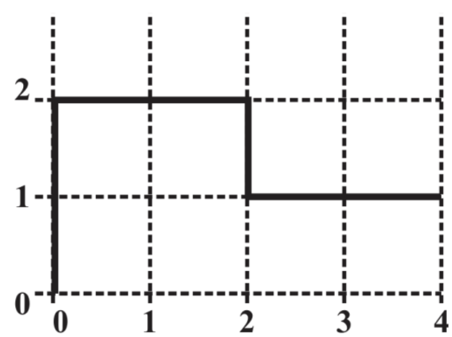


Use the drawing to the right for questions #4 and 5. Two masses are attached to the opposite ends of a string which is hung over a pulley as shown at the right. The masses of the string and pulley are insignificant. The mass 3m is released and accelerates to the floor causing mass 2m to accelerate upward.

4. How long will it take for the 3m mass to reach the floor?
   A. $\sqrt{\frac{10h}{g}}$ B. $\sqrt{\frac{12h}{g}}$ C. $\sqrt{\frac{8h}{g}}$ D. $\sqrt{\frac{7h}{g}}$ E. $\sqrt{\frac{5h}{g}}$

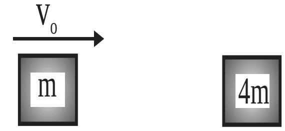
5. What will be the tension T in the string as the system accelerates?
   A. 5·mg B. 2·mg C. $^{12}/_5$·mg D. $^3/_4$·mg E. $^4/_3$·mg

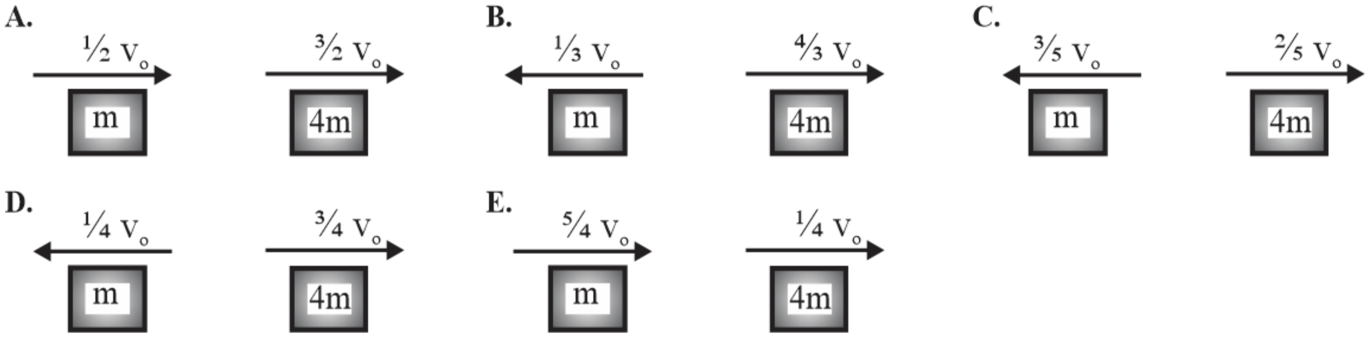
6. When an object is moved from rest at point A to rest at point B in a gravitational field, the net work done by the field depends on the mass of the object and _____________.
   A. the nature of the external force moving the object from A to B
   B. the velocity of the object as it moves between A and B
   C. both the positions of A and B and the path taken between them
   D. the path taken between A and B only
   E. the positions of A and B only



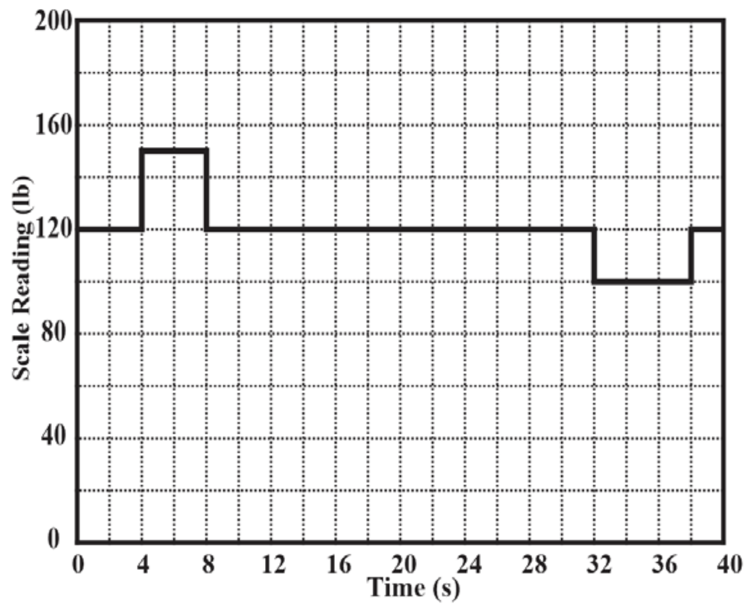
7. A wire of uniform density is bent into the shape shown to the right. Which of the following coordinate pairs (x,y) best locates the center of mass of this wire?
   A. (1.62,1.32) B. (1.32,1.55) C. (2.01,1.44)
   D. (1.88, 1.71) E. (1.43,1.36)

8. A block of mass m is initially sliding with speed v_o on a horizontal frictionless surface, as shown. It makes an elastic, head-on collision with another block of mass 4m that is initially at rest. Which of the following correctly shows the motion of the blocks after the collision?





An express elevator in a new skyscraper leaves the first floor and rises to the top floor of the building where it comes to rest. There is a bathroom scale in the elevator on which a student, who has a weight of 120 lb, is standing. The graph to the right plots the readings on the scale as the elevator goes from the first floor to the top floor.



9. What is the magnitude of the maximum acceleration of the elevator?
A. 0.8 m/s^2 B. 1.2 m/s^2 C. 1.8 m/s^2
D. 2.5 m/s^2 E. 2.8 m/s^2

10. What will be the distance between the 1st floor and the top floor?
A. 180 m B. 200 m C. 290 m
D. 320 m E. 360 m

-

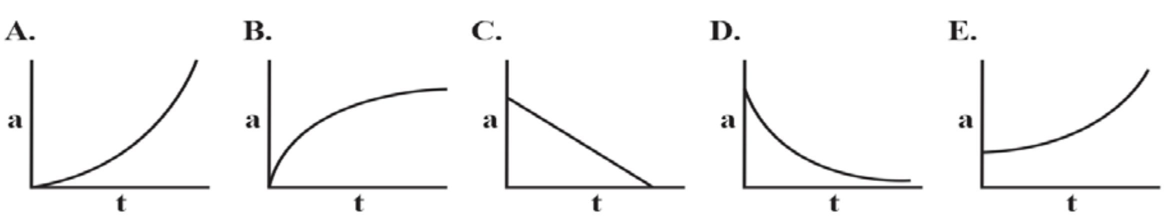
A very light ping-pong ball, which has a mass of 4.0 grams and a diameter of 3.8 cm, is dropped from rest from the top of a building 310 meters high. The ball moves smoothly through the air feeling a drag force that is directly proportional to the ball's speed $F_d = -bv$ where the drag coefficient is b = 0.0032 kg/s.

11. What will be the terminal velocity of the falling ping-pong ball?
A. 2.4 m/s B. 4.6 m/s C. 6.5 m/s D. 7.1 m/s E. 12.5 m/s

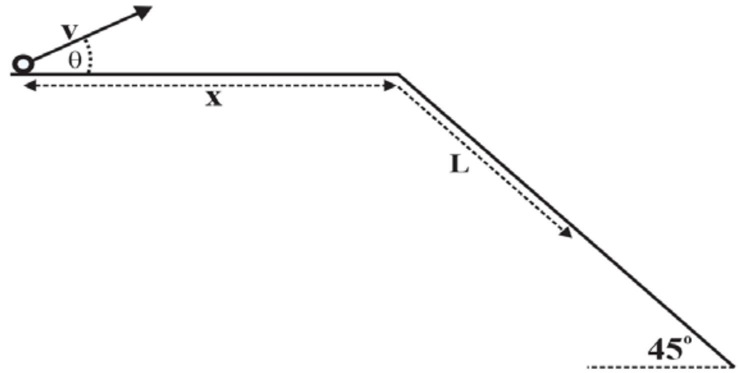
12. What will be the velocity of the ball 2.1 seconds after it has been dropped?
A. 3.68 m/s B. 10.2 m/s C. 12.2 m/s D. 15.5 m/s E. 18.8 m/s

13. Approximately how long will it take for the ball to strike the ground?
A. 9 s B. 13 s C. 18 s D. 26 s E. 42 s

14. Which of the following graphs best describes the acceleration of this falling ping-pong ball?



A small marble is fired upward at an angle θ = 30° with a speed of v_o from a point x = 1.5 m from the edge of a 45° downward slope. The marble lands at a point L = 1.41 m down the slope.



15. What was the initial velocity $\mathbf{v_o}$ of the marble?
 A. 3.2 m/s B. 4.1 m/s C. 4.9 m/s
 D. 5.2 m/s E. 5.7 m/s

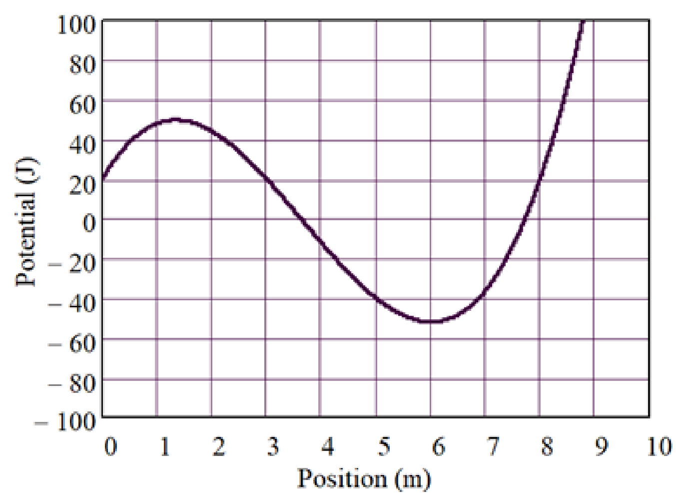
16. A 1520 W [2 HP] electric motor lifts a 150 kg safe at constant velocity. The vertical distance through which the motor can raise the safe in 20 s is most nearly ___________. All full credit. Constant velocity cannot be seen.
 A. 5 m B. 10 m C. 20 m D. 25 m E. 30 m

17. Two objects are dropped from rest from the same height. Object A falls through a distance d_A during a time t, and object B falls through a distance d_B during a time 3t. If air resistance is negligible, what is the relationship between d_B and d_A?
 A. d_B = 9dA B. d_B = 3dA C. d_B = 8dA D. d_B = dA/9 E. d_B = dA/3

The potential energy function in an area of space under the influence of an unknown conservative force is given by

$$U(x) = 2x^3 - 22x^2 + 48x + 20$$

and is described by the graph to the right.

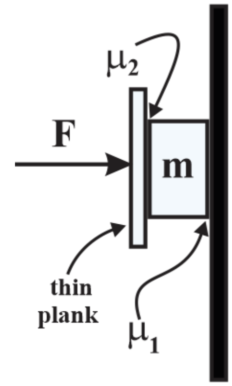


18. At which of the following positions will an object subject to this potential energy function be at an unstable equilibrium?
 A. 3.02 m B. 1.33 m C. 3.81 m
 D. 6.00 m E. 7.52 m

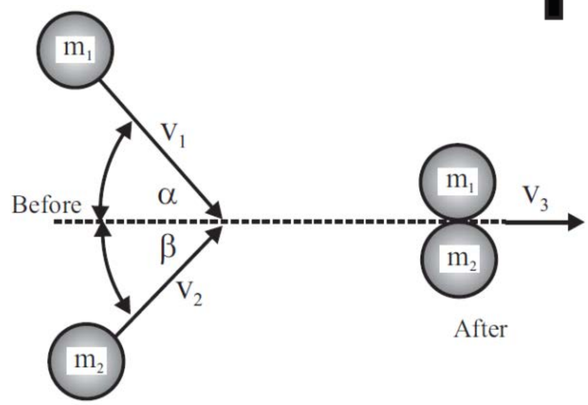
19. What will be the acceleration of a 5.0 kg mass placed at the position x = 8.0 m?
 A. 31.4 m/s^2 B. 23.8 m/s^2
 C. -12.5 m/s^2 D. -16.0 m/s^2 E. -23.8 m/s^2

20. Suppose that when this 5.0 kg mass is located at x = 6.0 m, it is moving with a velocity of 5.4 m/s. Which of the following ranges of positions is possible for this particle?
 A. (4.0m ↔ 7.5m) B. (5.0m ↔ 7.0m) C. (3.0m ↔ 8.0m) D. (3.7m ↔ 7.7m) E. (2.0m ↔ 7.5m)

21. A horizontal force F pushes a thin plank against a block of mass m against a vertical wall. The coefficient of static friction between the block and the wall is μ_1 while the coefficient of static friction between the block and the thin plank is μ_2. What value of F is necessary to keep the block from slipping down the wall?
A. $mg/(\mu_1 + \mu_2)$ B. $mg\cdot(\mu_1 + \mu_2)$ C. $mg\cdot(\mu_1/\mu_2)$
D. $mg\cdot(1 - \mu_1/\mu_2)$ E. $mg\cdot(1 + \mu_1/\mu_2)$



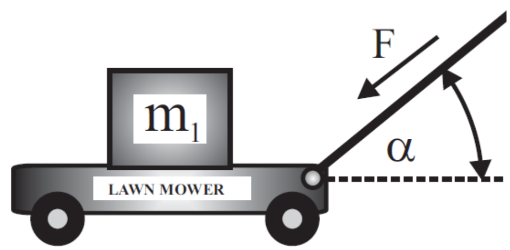
Two balls are approaching one another as shown in the diagram at the right. The first ball has a mass of $m_1 = 3.0$ kg and is moving with a velocity of $v_1 = 6.1$ m/sec at an angle of $\alpha = 33^o$ while a second ball has a mass $m_2 = 5.0$ kg and is moving with a velocity of $v_2 = 2.2$ m/sec at an angle β. After the collision, the two balls stick together and move off toward the right at a new speed v_3. Use the diagram for #s 22 and 23.



22. What is the angle β between velocity v_2 and the x axis?
A. 42^o B. 51^o C. 58^o D. 65^o E. 71^o

23. What will be the final velocity v_3 after the collision?
A. 6.2 m/s B. 5.8 m/s C. 5.3 m/s D. 2.5 m/s E. 1.9 m/s

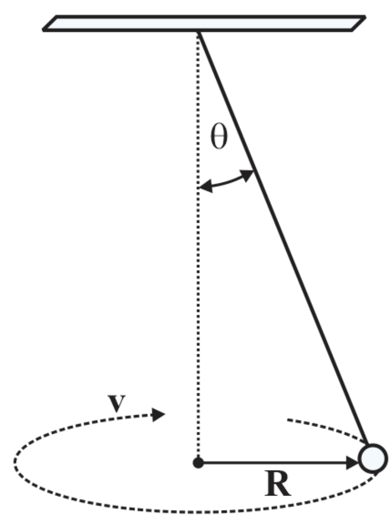
A lawn mower, which has a mass of $m_1 = 28.0$ kg, is being pushed with a force of F = 122 N being applied to the handle which meets the horizontal at an angle of $\alpha = 33.0^o$. As a result, the mower moves toward the left at a constant speed of v = 2.20 m/sec.



24. How much work will be done by the applied force as the mower is pushed forward for 8.0 seconds?
A. 880 J B. 1200 J C. 1300 J D. 1500 J E. 1800 J

A mass m = 100 gm is attached to the end of a string. The mass is given a push so that it moves in a conical path with a speed v = 1.45 m/s in a circle with a radius R = 31.0 cm as shown to the right.

25. What will be the angle θ between the string and the vertical?
A. 15^o B. 22^o C. 34^o D. 39^o E. 42^o



Physics C Answer Key: **Orchid Test**
Date Jan 11, 2018 Corrections
Solutions

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

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 2018 Season

Thursday January 11, 2018 Thursday February 8, 2018
Thursday March 8, 2018 Thursday April 12, 2018
All areas and schools must complete the April exam and mail in the results
by April 28th, 2018

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 for 2019 Season

Thursday January 10, 2019 Thursday February 7, 2019
Thursday March 7, 2019 Thursday April 11, 2019

ADVANCED PLACEMENT PHYSICS C EQUATIONS

updated 12-20-2017

MECHANICS

$v_x = v_{x0} + a_x t$

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

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

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

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

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

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

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

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

$K = \frac{1}{2} m v^2$

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

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

$\Delta U_g = mg\Delta h$

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

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

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

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

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

$v = r\omega$

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

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

$\omega = \omega_0 + \alpha t$

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

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

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

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

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

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

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

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

$|\vec{F}_G| = \frac{G m_1 m_2}{r^2}$

$U_G = -\frac{G m_1 m_2}{r}$

ELECTRICITY AND MAGNETISM

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

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

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

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

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

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

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

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

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

$C_p = \sum_i C_i$

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

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

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

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

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

$I = N e v_d A$

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

$R_s = \sum_i R_i$

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

$P = I \Delta V$

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

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

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

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

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

$B_s = \mu_0 n I$

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

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

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

$U_L = \frac{1}{2} L I^2$

ADVANCED PLACEMENT PHYSICS C EQUATIONS

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

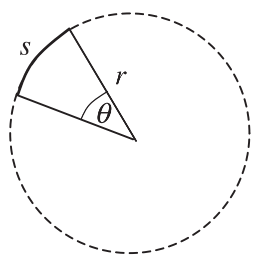
$a^2 + b^2 = c^2$

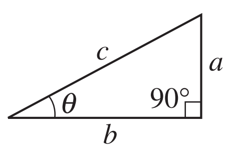
$\sin\theta = \frac{a}{c}$

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

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

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

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

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

No Corrections

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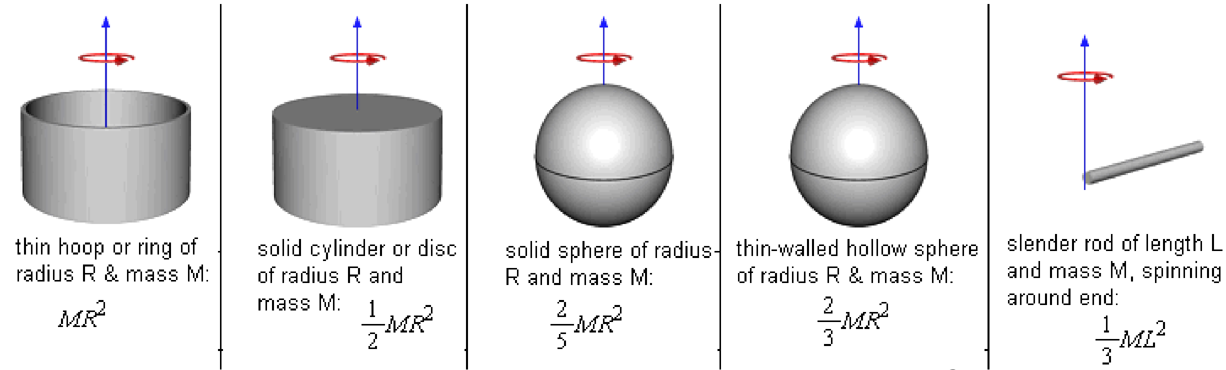
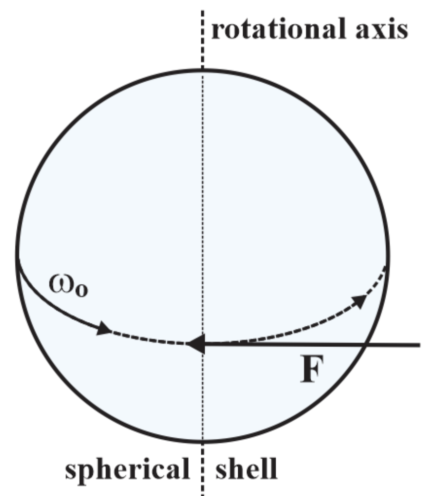
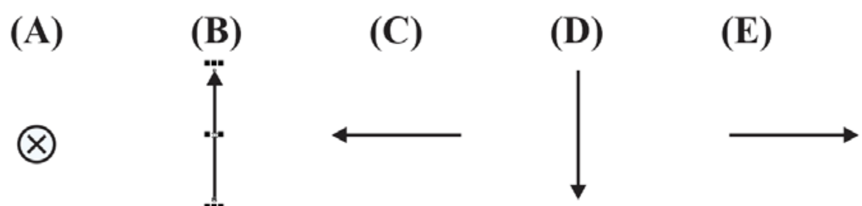


counterclockwise is positive. Sketches are not to scale. Assume g = 10m/s^2 and the following moments of inertia:

A thin walled hollow sphere, which has a mass of 4.5 kg and a radius of 38 cm, is initially rotating counter-clockwise at 3.5 revolutions per second about a vertical rotational axis. Beginning at t = 0 s, a constant external force of F = 24 N is applied tangentially to the edge of the sphere's equator for 12 seconds as shown in the diagram to the right.



1. What is the direction of the spherical shell's initial angular velocity vector?



2. What is the angular acceleration of the spherical shell during the time that the external force is applied?
   (A) -21 rad/s²   (B) -15 rad/s²   (C) -26 rad/s²   (D) 14 rad/s²   (E) 15 rad/s²

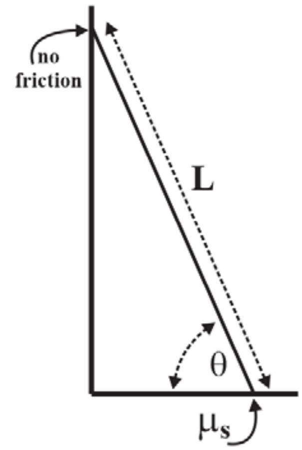
3. What will be the angular momentum of the spherical shell after the external force has been applied for t = 12 seconds?
   (A) -100 kg·m²/s   (B) -200 kg·m²/s   (C) 330 kg·m²/s
   (D) 475 kg·m²/s   (E) -475 kg·m²/s

4. What will be the final angular displacement of the spherical shell after 20 seconds?
   (A) 2600 rad   (B) -3500 rad   (C) -1850 rad   (D) -3100 rad   (E) 1850 rad

An external braking torque is then applied to the spherical shell bringing it to rest in 10 seconds.

5. What is the average power supplied by this external torque in bringing the spherical shell to rest?
   (A) 1250 W   (B) 1790 W   (C) 1150 W   (D) 1620 W   (E) 3150 W

A ladder, which has a length L = 5.4 m and a mass of M = 38 kg, is leaning against a frictionless wall at an angle θ = 62° relative to the ground as shown to the right. A house painter whose mass is m = 52 kg is to safely climb to the top of the ladder without the ladder slipping.



6. What is the minimum coefficient of static friction μ_s between the ladder and the ground so that the ladder will not slip?
   (A) 0.33 (B) 0.37 (C) 0.42 (D) 0.55 (E) 0.62

7. Which of the following can be used to distinguish a solid sphere from a hollow sphere of the same radius and mass?
   (A) Measurements of how long it takes for each object to roll without slipping to the bottom of an inclined plane.
   (B) Measurements of the orbital velocity of each object as each orbits the same central mass.
   (C) Measurements of the tidal forces applied by the object to a liquid body.
   (D) Measurements of the behavior of each object as it floats in a liquid whose density is greater than the average density of each object.
   (E) Measurements of how high each object can be projected from a compressed vertical spring of known spring constant.

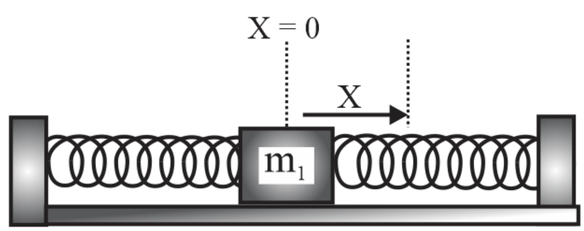
A crude approximation is that Saturn travels in a circular orbit about the Sun at constant speed, at an average distance of 1.43×10^{12} m from the Sun. [See the data table]

PLANET	Radius	Mass	Orbital Radius
Sun	6.96×10^{8} m	1.99×10^{30} kg	N/A
Saturn	6.00×10^{7} m	5.68×10^{26} kg	1.43×10^{12} m
Universal gravitational constant		$G = 6.67 \times 10^{-11}$ Nm^2/kg^2	
1 yr = 3.156×10^{7} sec			

8. Which of the following is the closest to the centripetal acceleration of Saturn in its orbit about the Sun?
   (A) 1.0043 m/s^2 (B) 0.000187 m/s^2 (C) 0.0033 m/s^2 (D) 0.000065 m/s^2 (E) 0.00292 m/s^2

9. What is the orbital period of Saturn about the Sun?
   (A) 116 yrs (B) 29.6 yrs (C) 23.7 yrs (D) 19.2 yrs (E) 12.9 yrs

A low friction cart, which has a mass of 4.0 kg, is located in the center of a horizontal track. It is connected to each end of the track by two identical springs, each with a spring constant k = 44 N/m. The car is displaced x = 30 cm to the right of its equilibrium position and is then released.



10. What will be the frequency of the resulting oscillations?
    (A) 0.24 Hz (B) 0.53 Hz (C) 1.15 Hz (D) 0.75 Hz (E) 1.65 Hz

11. What would happen to the frequency of the oscillations, if the maximum displacement of the cart is doubled to 60 cm?
    (A) The frequency would double.
    (B) The frequency would quadruple.
    (C) The frequency would be halved.
    (D) The frequency would be unchanged
    (E) The frequency would decrease by the square root of 2.

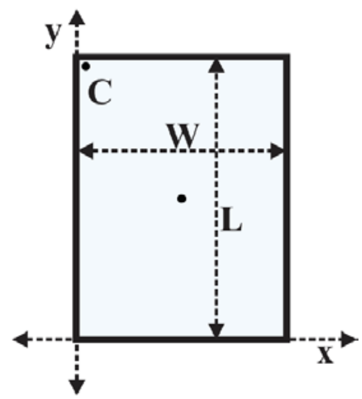
A star, which has a mass of 6.0 x 10^{30}kg and a radius of 4.8 x 10^{9}m, rotates on its axis once every 6.0 days. This star then undergoes a gravitational collapse until its radius has been reduced to 2.4 x 10^{7}m.

12. What will be the resulting rotational period of the star after its collapse?
    (A) 4.2 days (B) 1.20 days (C) 8.2 hrs (D) 13.0 s (E) 0.0025 s

Suppose that this star continues to collapse until it becomes a black hole.

13. What will be the radius of this star when it collapses into a black hole?
    (A) 8.25 x 10^4m (B) 3.22 x 10^4m (C) 1.05 x 10^4m
    (D) 8.89 x 10^3m (E) 6.23 x 10^3m

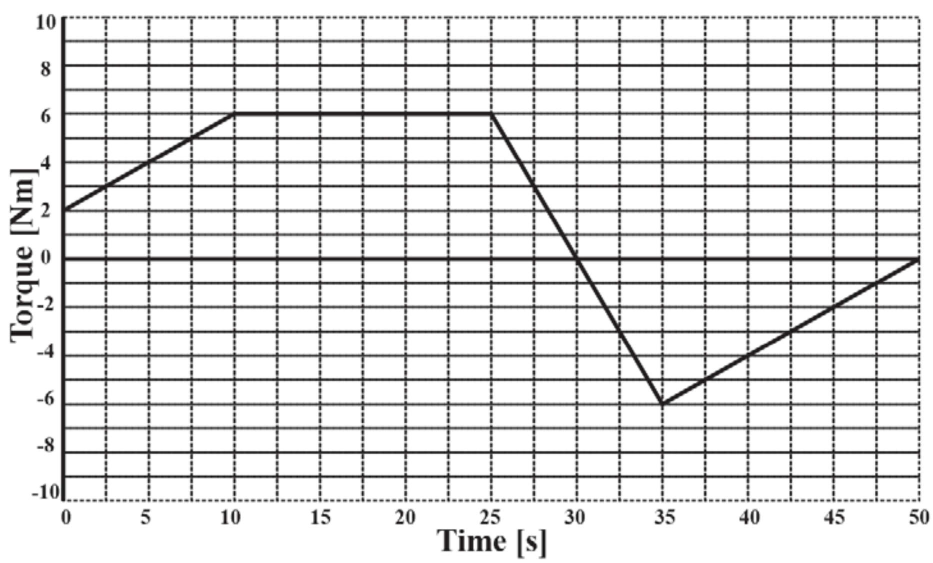
A uniform rectangular plate, which has a length L = 54 cm, a width W = 38 cm and mass of m = 2.5 kg, is pivoted about an axis perpendicular to the plate and through point C as shown.



14. What is the moment of inertia of this plate about the y axis?
    (A) 0.78 kg·m^2 (B) 0.45 kg·m^2 (C) 0.36 kg·m^2
    (D) 0.23 kg·m^2 (E) 0.12 kg·m^2

15. What is the moment of inertia of the plate about an axis perpendicular to and through the top left corner of the plate?
    (A) 0.78 kg·m^2 (B) 0.45 kg·m^2 (C) 0.36 kg·m^2
    (D) 0.23 kg·m^2 (E) 0.12 kg·m^2

A flywheel which has a moment of inertia I = 5.0 kgm^2 and is rotating clockwise with an angular velocity of ω = -7.0 rad/s. An external torque is applied for a period of 50 seconds as shown in the graph to the right.



16. What will be the angular velocity of the flywheel at the end of the 50 second period?
    (A) 41 rad/s (B) 34 rad/s
    (C) 48 rad/s (D) 10 rad/s
    (E) 24 rad/s

17. What is the angular acceleration of this flywheel when t = 40s?
    (A) 2.5 rad/s^2 (B) -2.5 rad/s^2 (C) -0.8 rad/s^2 (D) -1.2 rad/s^2 (E) -1/8 rad/s^2

A particle moves in a circle in such a way that the x and y coordinates of its motion, given in meters as functions of time t in seconds, are: x = 6 cos(4π·t) and y = 6 sin(4π·t).

18. How long does it take this particle to complete one circle?
    (A) 2·π s (B) 0.5 s (C) 2.0 s (D) π s (E) 4.0 s

19. What will be the centripetal acceleration [in m/s^2] of this particle?
    (A) 36·π^2 (B) 96·π^2 (C) 240·π^2 (D) 480·π^2 (E) 24·π^2

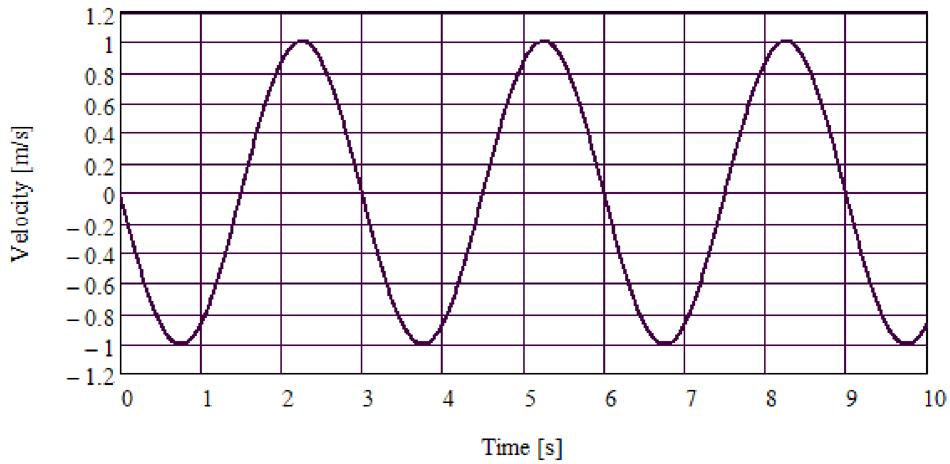
A solid disk, which has a radius of R = 30 cm, has a mass density σ that varies with distance from the center of the disk according to:

$$\sigma = a + b \cdot r^2 \text{ where } a = 12 \cdot kg/m^2 \text{ and } b = 220\ kg/m^4$$

20. What is the total mass of the disk?
(A) 1.4 kg (B) 2.8 kg (C) 4.5 kg (D) 6.2 kg (E) 7.1 kg

21. What will be the moment of inertia of the disk about an axis through the center of mass and perpendicular to the plane of the disk?
(A) 0.45 kgm^2 (B) 1.13 kgm^2 (C) 0.32 kgm^2 (D) 2.93 kgm^2 (E) 4.40 kgm^2

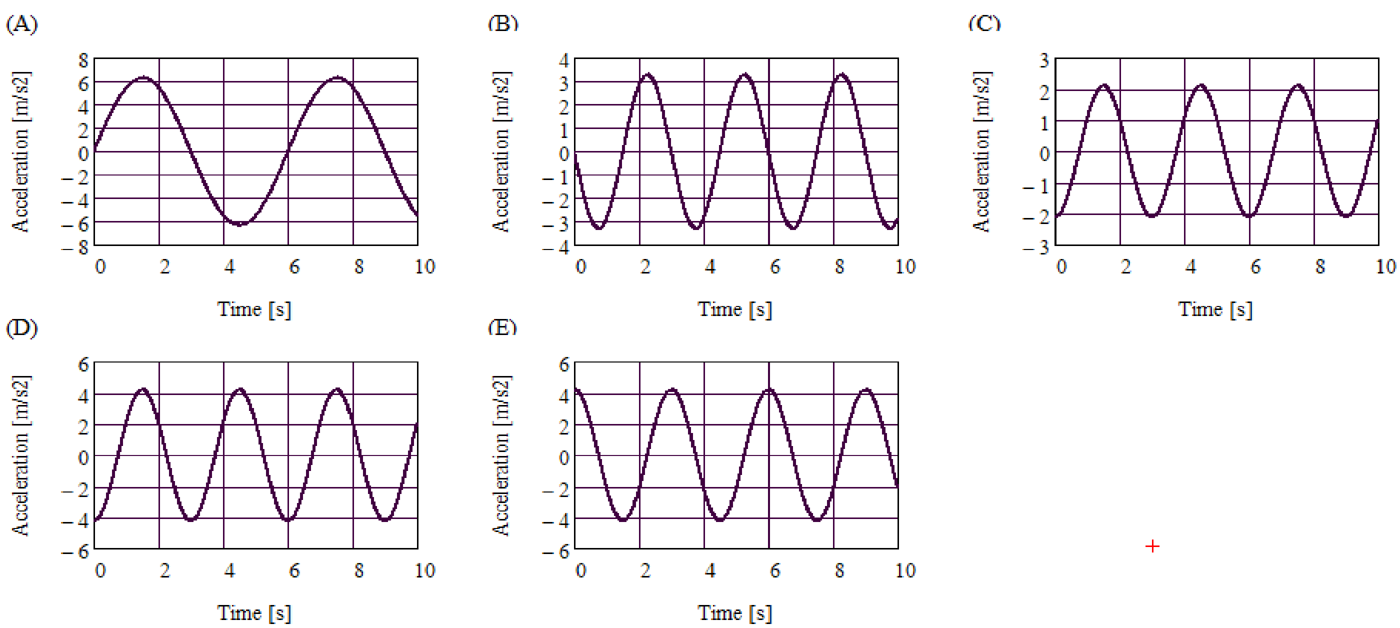
A simple pendulum is pulled back to an angle θ and is then released from rest. The graph to the right shows the velocity of this simple pendulum as a function of time.



22. What is the length of this simple pendulum?
(A) 2.28 m (B) 1.53 m
(C) 1.88 m (D) 3.15 m
(E) 2.40 m

23. What is the angle θ to which this simple pendulum has been pulled back before its release?
(A) 12^o (B) 4^o (C) 9^o (D) 15^o (E) 7.5^o

24. Which of the following graphs best shows the tangential acceleration of this simple pendulum as a function of time?



25. A newly discovered planet has a mass M distributed uniformly throughout a spherical volume which has a radius R. The acceleration at the surface of this planet is measured to be g. What would be the gravitational acceleration at a distance of R/3 from the center of the planet?
(A) 3g (B) g/3 (C) 9g (D) g/9 (E) g/8

ADVANCED PLACEMENT PHYSICS C EQUATIONS

updated 12-20-2017

MECHANICS

$v_x = v_{x0} + a_x t$

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

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

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

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

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

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

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

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

$K = \frac{1}{2} m v^2$

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

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

$\Delta U_g = mg\Delta h$

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

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

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

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

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

$v = r\omega$

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

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

$\omega = \omega_0 + \alpha t$

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

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

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

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

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

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

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

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

$\left|\vec{F}_G\right| = \frac{G m_1 m_2}{r^2}$

$U_G = -\frac{G m_1 m_2}{r}$

ELECTRICITY AND MAGNETISM

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

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

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

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

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

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

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

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

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

$C_p = \sum_i C_i$

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

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

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

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

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

$I = N e v_d A$

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

$R_s = \sum_i R_i$

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

$P = I\Delta V$

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

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

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

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

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

$B_s = \mu_0 n I$

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

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

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

$U_L = \frac{1}{2} L I^2$

ADVANCED PLACEMENT PHYSICS C EQUATIONS

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

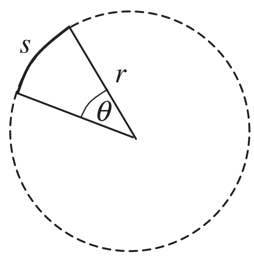
$a^2 + b^2 = c^2$

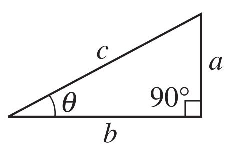
$\sin\theta = \frac{a}{c}$

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

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

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>** No Corrections

Date Feb 8, 2018

Solutions

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

<u>Dates for 2018 Season</u>

Thursday February 8, 2018
Thursday March 8, 2018 Thursday April 12, 2018
All areas and schools must complete the April exam and mail in the results by April 28th, 2018

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 <u>AND</u> ALL TEAM MEMBER SCANTRONS (ALL STUDENTS PLACING 1ST, 2ND, 3RD, AND 4TH).
If you return Scantrons of alternates, then label them as ALTERNATES.

<u>Dates for 2019 Season</u>

Thursday January 10, 2019 Thursday February 7, 2019
Thursday March 7, 2019 Thursday April 11, 2019

Physics C Science League Test <u>Orchid Test</u>

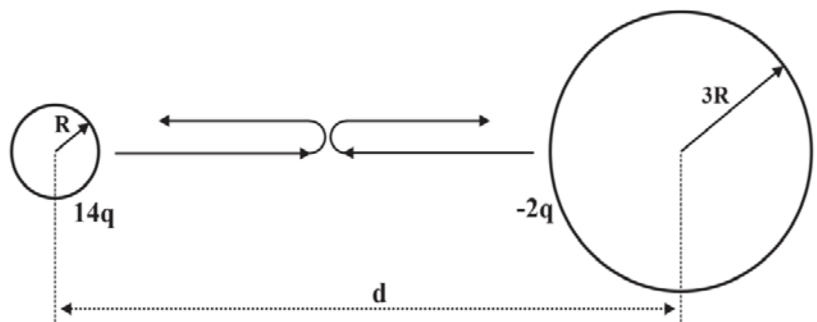
March 8, 2018

No Corrections

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 otherwise stated, assume ideal conditions including no friction with the air. Sketches are not to scale.

[Useful constants: $k = 1/(4\pi\varepsilon_o) = 9.0 \times 10^9$ Nm^2/C^2, $\varepsilon_o = 8.85 \times 10^{-12}$ C^2/(Nm^2)]

Two small conducting spheres are located a distance d apart. The left sphere (L) has a radius R and contains a charge 14q while the right sphere (R) has a radius 3R and contains a charge -2q. The force exerted on each sphere by the other has magnitude F. These two spheres are brought together until they touch and are then moved apart to a new separation distance of 3d.

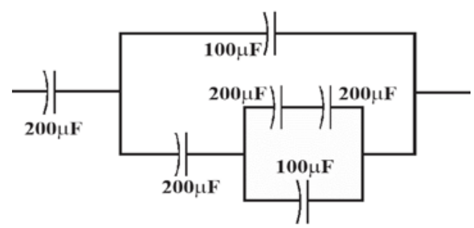


1. What will be the final charge on each sphere (L,R) after being moved to their new positions?
   A. 6q,6q B. 12q,4q C. 4q,12q D. 16q,14q E. 3q,9q

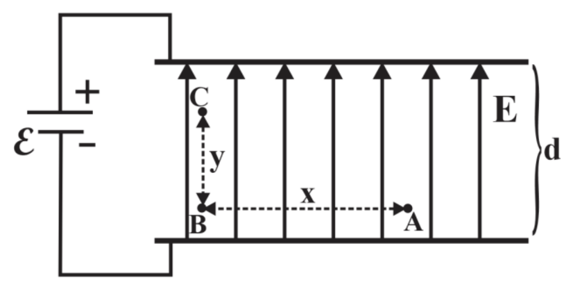
2. What will be the magnitude of the ratio of the forces between these two spheres before and after contact?
   A. 12/28 B. 16/12 C. 27/28 D. 16/9 E. 3/28

---

3. What will be the **<u>total</u>** capacitance of the network to the right?
   A. 50 μF B. 100 μF C. 150 μF D. 200 μF E. 400 μF



Two parallel plates are separated by a distance d = 15 cm and are attached to a battery that has an EMF of $\mathcal{E}$ = 300 Volts. A small conducting sphere which has a mass of m = 0.10 grams and a charge of q = 100 μC is initially located at point A. The sphere is then moved a distance x = 12 cm to point B and is then moved a distance y = 10.0 cm to point C.



4. How much work is done by moving this sphere from point A to point C?
   A. 0.22 J B. 0.085 J C. 0.044 J
   D. 0.050 J E. 0.020 J

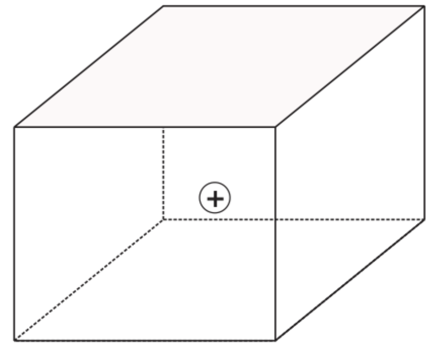
The sphere, located at rest at point C, is then released and accelerates back to point B.

5. What will be the speed of the sphere when it reaches point B?
   A. 20 m/s B. 24 m/s C. 19 m/s D. 15 m/s E. 11 m/s

---

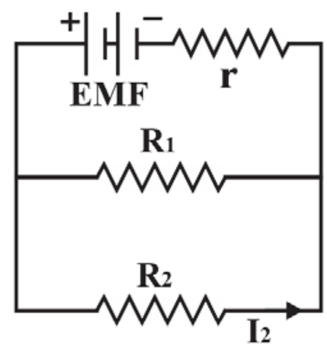
6. Which of the following is a possible equivalent unit for electric field?
   A. $\frac{N}{A\cdot m\cdot s}$ B. $\frac{N}{A\cdot m}$ C. $\frac{J}{C\cdot m\cdot s}$ D. $\frac{J\cdot s}{A\cdot m}$ E. $\frac{J}{A\cdot m\cdot s}$

7. The point charge +Q shown to the right is at the center of a metal box that is isolated, ungrounded, and contains a net charge +3Q. Which of the following is true?
   A. The net charge on the outside surface of the box is +4Q.
   B. The electric field outside the box is the same as if only the point charge (and not the box) were there.
   C. The electric field inside the box is radially outward from the charge +Q at all points.
   D. The electric field outside the box is zero everywhere.
   E. The potential inside the box is zero everywhere.



In the circuit to the right, the circuit elements have the following values:

EMF = 24 V R_1 = 60 Ω R_2 = 20 Ω I_2 = 0.90 A

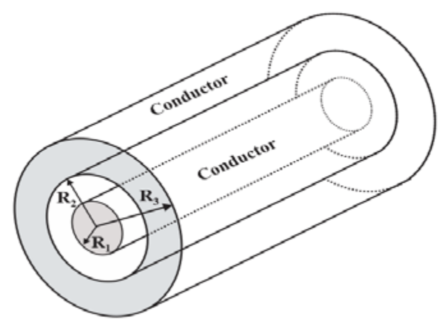


8. What is the internal resistance r of the battery?
   A. 6.0 Ω B. 2.5 Ω C. 3.0 Ω D. 5.0 Ω E. 1.0 Ω

9. What will be the reading on a voltmeter connected across the battery?
   A. 24 V B. 18 V C. 16 V D. 12 V E. 9.0 V

10. How much heat will be dissipated within the battery during a 5-minute period?
   A. 1250 J B. 1830 J C. 2160 J D. 3130 J E. 5410 J

Each of the following questions refers to the diagram to the right which consists of two concentric, conducting cylinders each with a length of L = 3.0 meters. The inner cylinder has a radius of R_1 = 4.0 cm and contains 30 μC of charge for each meter of length while the outer cylinder has an inner radius of R_2 = 8.0 cm, an outer radius of R_3 = 12 cm and contains -30 μC per meter of length.



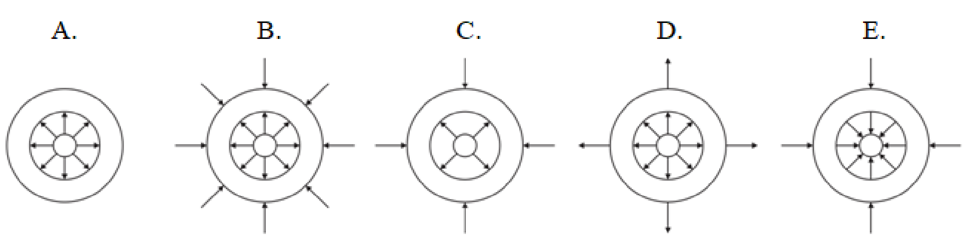
11. What is the electric field strength 6.0 cm from the center of the inner cylinder?
   A. 3.0×10^6 N/C B. 3.0×10^7 N/C C. 9.0×10^6 N/C
   D. 4.5×10^7 N/C E. 7.5×10^6 N/C

12. What is the charge density per unit area σ_3 on the <u>outer surface</u> of the outer cylindrical shell?
   A. 10 μC/m² B. 20 μC/m² C. 60 μC/m² D. 0 μC/m² E. -60 μC/m²

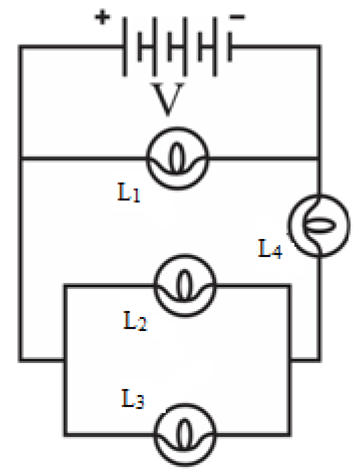
13. What will be the potential difference between the inner cylinder and the outer cylindrical shell?
   A. 2.2×10^4 V B. 3.7×10^5 V C. 2.2×10^5 V D. 4.1×10^5 V E. 5.0×10^5 V

14. What is the capacitance of this cylindrical capacitor?
   A. 2.4×10^{-4} μF B. 4.0×10^{-4} μF C. 6.0×10^{-6} μF D. 6.2×10^{-5} μF E. 9.2×10^{-4} μF

15. Which of the following best illustrates the electric field in the area surrounding these two cylinders?



The following question refers to the circuit at the right consisting of 4 different light bulbs connected to a battery with negligible internal resistance. Initially, all four lightbulbs are emitting light normally. Suppose that suddenly lightbulb L_2 is unscrewed, and of course, goes out.



16. What will happen to the other 3 lightbulbs?
   A. L_1 – brighter L_3 – no change L_4 – no change
   B. L_1 – brighter L_3 – brighter L_4 – dimmer
   C. L_1 – no change L_3 – no change L_4 – brighter
   D. L_1 – dimmer L_3 – brighter L_4 – brighter
   E. L_1 – no change L_3 – brighter L_4 – dimmer

A 60 μF capacitor consists of two parallel plates filled with an insulator that has a dielectric constant of K = 6. This capacitor is attached to a battery which has an EMF of 12.0 Volts.

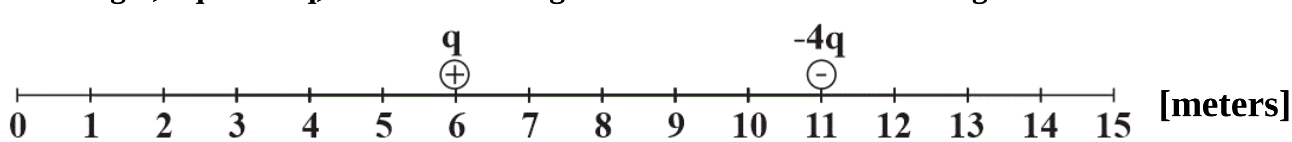
While remaining attached to the battery, the insulator is suddenly pulled out from between the two plates of the capacitor.

17. What is the magnitude of the additional charge that will flow on/off the positive plate of the capacitor while removing the insulator?
   A. 150 μC B. 600 μC C. 250 μC D. 240 μC E. 40 μC

Instead, the capacitor is first disconnected from the battery and then the insulator is suddenly pulled out from between the two plates of the capacitor.

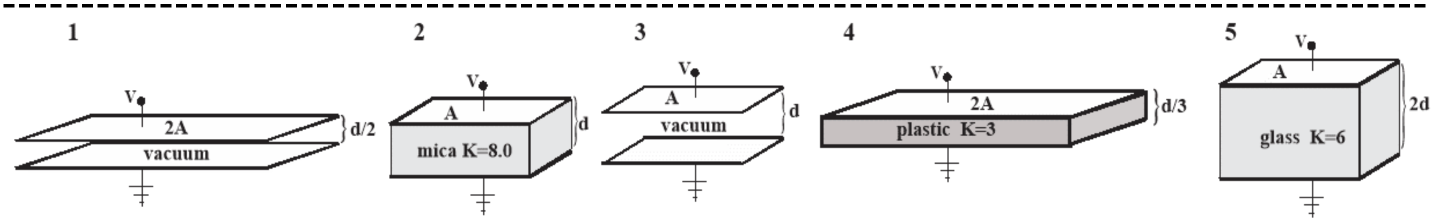
18. How much work will be required to remove the insulator from between the plates?
   A. 0.022 J B. 0.0029 J C. 0.055 J D. 0.017 J E. 0.315 J

Two charges, +q and -4q, are located along the x-axis as shown in the diagram below:



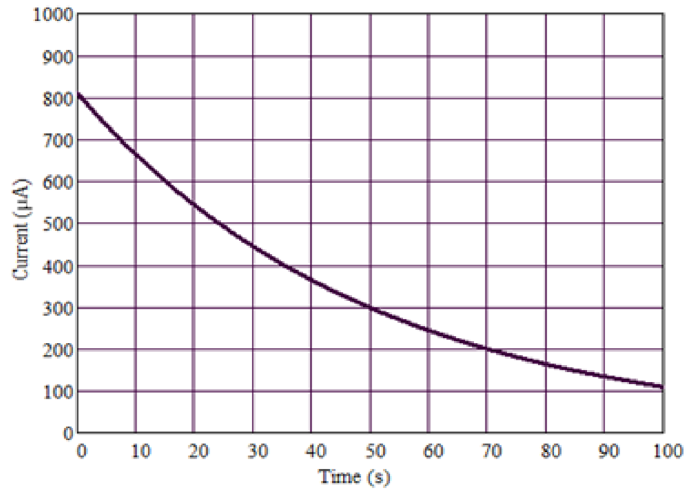
19. Where along the x-axis will the electric field be zero?
   A. 13 B. 10 C. 7 D. 4 E. 1

20. Where along the x axis will the electric potential be zero?
   A. 13 B. 10 C. 7 D. 4 E. 1



21. Rank the above capacitors from the <u>greatest to least</u> capacitance!
   A. 4→5→1→3→2 B. 1→3→5→2→4 C. 4→2→1=5→3
   D. 4→2→1→5→3 E. 4→1→5→3→2

A capacitor C is initially attached to a battery which has an EMF of V_o = 12.0 Volts. The capacitor is then removed from the battery and is attached to an external resistor R and a micro ammeter. The initial current through the resistor R is 810 μA which then decreases as a function of time as plotted on the graph to the right.

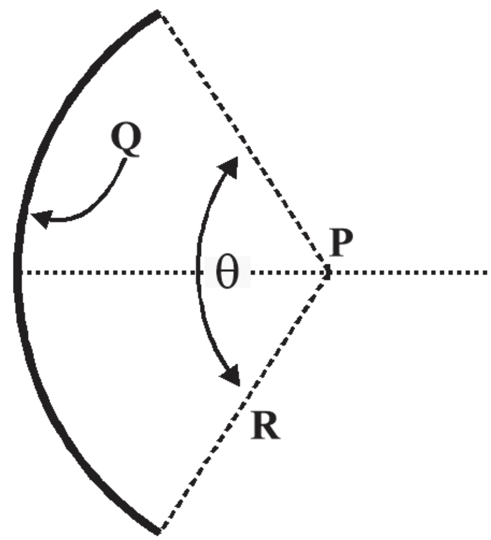


22. How much charge was initially stored on the capacitor?

A. 40,500 μC B. 18,600 μC
C. 38,200 μC D. 62,000 μC
E. 212,000 μC

23. What will be the voltage drop across the resistor 200 seconds after being connected to the capacitor?
A. 10.5 V B. 8.2 V C. 7.1 V D. 0.22 V E. 0.024 V

A charge of Q = 50 μC is distributed evenly along the length of a curved section of wire which has a radius of R = 10 cm and which symmetrically subtends an angle of θ = 2.00 radians as shown to the right.



24. Which of the following expressions correctly gives the electric field at point P?

A. $\frac{kQ}{R}\cdot\cos(\theta)$ B. $\frac{kQ}{R}\cdot\sin(\theta)$ C. $\frac{kQ}{R^2}\cdot\sin(\theta/2)$
D. $\frac{2kQ}{R^2}\cdot\cos(2\theta)$ E. $\frac{kQ}{R^3}\cdot\sin(\theta/2)$

An alpha particle [mass = 6.64×10^{-27} kg, charge = 3.20×10^{-19}C] is placed at rest at point P and is then released.

25. What will be the velocity of the alpha particle when it is 100 meters to the right of the charged wire?
A. 2.1×10^7 m/s B. 8.8×10^6 m/s C. 7.1×10^6 m/s
D. 5.5×10^5 m/s E. 5.5×10^6 m/s

ADVANCED PLACEMENT PHYSICS C EQUATIONS updated 12-20-2017

MECHANICS

$v_x = v_{x0} + a_x t$

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

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

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

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

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

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

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

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

$K = \frac{1}{2} m v^2$

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

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

$\Delta U_g = mg\Delta h$

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

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

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

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

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

$v = r\omega$

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

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

$\omega = \omega_0 + \alpha t$

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

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

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

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

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

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

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

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

$|\vec{F}_G| = \frac{G m_1 m_2}{r^2}$

$U_G = -\frac{G m_1 m_2}{r}$

ELECTRICITY AND MAGNETISM

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

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

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

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

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

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

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

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

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

$C_p = \sum_i C_i$

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

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

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

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

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

$I = N e v_d A$

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

$R_s = \sum_i R_i$

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

$P = I\Delta V$

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

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

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

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

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

$B_s = \mu_0 n I$

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

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

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

$U_L = \frac{1}{2} L I^2$

ADVANCED PLACEMENT PHYSICS C EQUATIONS

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

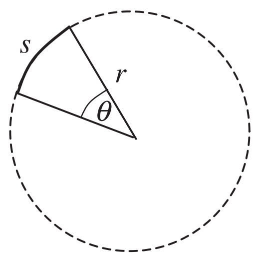
$a^2 + b^2 = c^2$

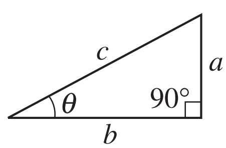
$\sin\theta = \frac{a}{c}$

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

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

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

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

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

Physics C Answer Key: **Orchid Test No Corrections**

Date March 8, 2018

Deadline: All March exam results must be post marked by March 16th or scan the record sheet and email to newjsl@ptd.net or the scores will not count.

1	E	6	E	11	C	16	E	21	D
2	E	7	A	12	D	17	B	22	A
3	B	8	D	13	B	18	A	23	D
4	E	9	B	14	A	19	E	24	C
5	A	10	C	15	A	20	C	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 2018 Season

Thursday March 8, 2018 Thursday April 12, 2018

All areas and schools must complete the April exam and mail in the results by April 28th, 2018

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 for 2019 Season

Thursday January 10, 2019 Thursday February 7, 2019
Thursday March 7, 2019 Thursday April 11, 2019

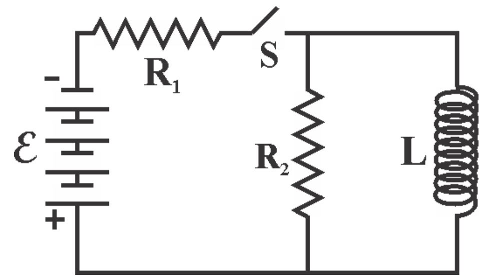
DIRECTIONS: Please PRINT your name, school, area, and which test you are taking on the Scantron. For each statement or question, completely fill in the appropriate space on the answer sheet. Use the letter preceding the word or phrase or sketch which best completes the statement or answers the question. Unless otherwise stated, assume ideal conditions and that ✖ indicates a vector directed into the page and ● indicates a vector out of the page. Sketches are not to scale. Corrections

[Useful constants; $\mu_o = 4\cdot\pi x 10^{-7}$ T·m/A
$k_m = \mu_o/(4\cdot\pi) = 10^{-7}$ A/(T·m) 10^4 Gauss = 1 Tesla e = 1.6 x 10^{-19} C]

Each of the following questions refers to the circuit to the right where the switch S is open and circuit elements have values:

$\mathcal{E}$ = 30 V R_1 = 100 Ω R_2 = 900 Ω L = 200 mH

At t = 0s, switch S is closed.



1. What will be the voltage across R_2 immediately after the switch S is closed?
   A. 0 V B. 12 V C. 18 V D. 24 V E. 27 V

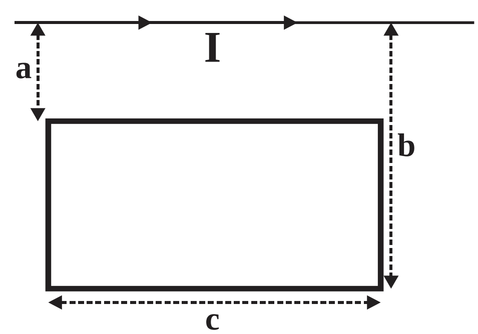
Assume now that the switch has been closed for a long time.

2. What will be the voltage across R_2 a long time after the switch has been closed?
   A. 0 V B. 12 V C. 24 V D. 27 V E. 30 V

After a long time, the switch is again re-opened.

3. What will be the voltage across R_2 immediately after the switch has been reopened?
   A. 24 V B. 27 V C. 30 V D. 60 V E. 270 V

A long straight wire is carrying a conventional current I as shown. Adjacent to this straight wire is a conducting rectangular loop with dimensions and position as shown. The current in the long, straight wire is increasing with time according to the relationship $I = I_o + \alpha\cdot t$ where α is a positive constant and where I_o is the current at t = 0 sec.



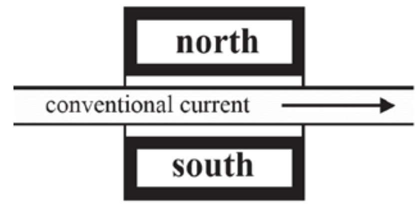
4. Which of the following expressions describes the magnetic flux through the loop as a function of time?

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

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

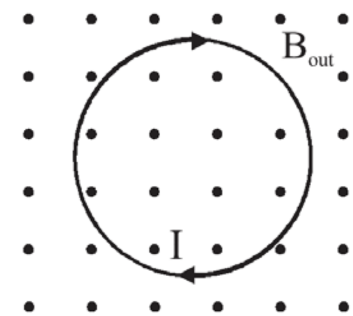
5. What will be the resulting effect on the loop of wire?
   A. There will be a gradually increasing clockwise current flow.
   B. There will be a constant clockwise current flowing in the loop.
   C. There will be no effect on the loop.
   D. The loop of wire will be repelled by the current-carrying wire.
   E. There will be a gradually decreasing counter-clockwise current flow.

6. A current-carrying wire is sitting between the poles of a magnet as shown to the right. Conventional current I is flowing towards the right. In what direction could an electric field be added so that the wire feels no net force?



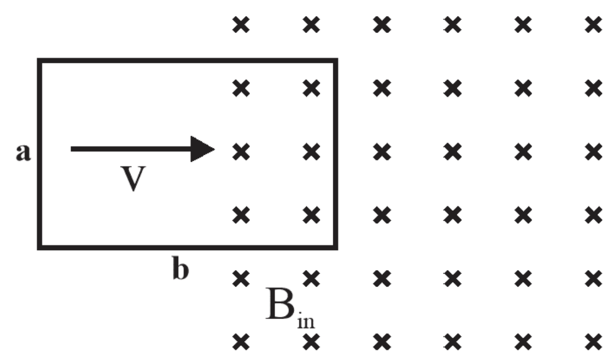
A. out of the page B. towards the left C. into the page
D. towards the right E. no such electric field exists

7. There is a counterclockwise current I in a circular loop of wire situated in an external magnetic field directed out of the page as shown. The effect of the forces that act on this current is to make the loop _______________ . A and E are correct. Diagram is clockwise while question say counterclockwise.



A. expand in size
B. accelerate into the page
C. rotate about an axis perpendicular to the page and through the center of the loop
D. rotate about an axis in the plane of the page and parallel to the y axis
E. contract in size

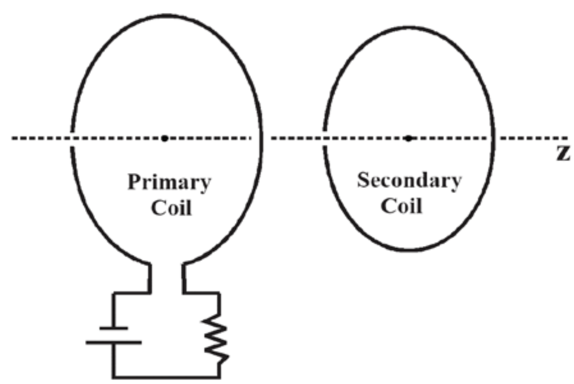
The figure to the right shows a rectangular loop of wire of width a, length b, and resistance R. One end of the loop is in a uniform magnetic field of strength B at right angles to the plane of the loop. The loop is pulled to the right at a constant speed v by a constant force F.



8. What are the magnitude of the required force F and the direction of the induced current in the loop?

	Magnitude Force	Direction Current
A.	$B \cdot a \cdot v/R$	Counterclockwise
B.	$B \cdot a \cdot v^2 \cdot R$	Counterclockwise
C.	$B^2 \cdot a^2 \cdot v/R$	Clockwise
D.	$B^2 \cdot a^2 \cdot v/R$	Counterclockwise
E.	$B \cdot a^2 \cdot v/R^2$	Clockwise

9. Two circular coils are situated perpendicular to the z-axis as shown. There is a current in the primary coil. All of the following procedures will induce a current in the secondary coil EXCEPT?

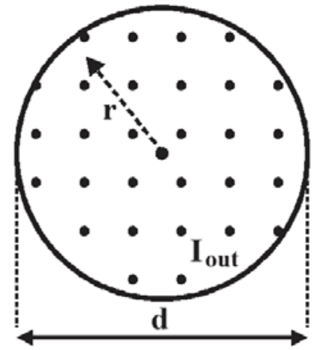


A. moving the secondary coil closer to the primary coil
B. rotating the secondary coil about its diameter
C. rotating the secondary coil about the z-axis
D. varying the current in the primary coil
E. decreasing the cross-sectional area of the secondary coil

A magnetic field of 0.030 T forces a proton beam of 1.5 mA to move in a circle of radius 0.035 m. The plane of the circle is perpendicular to the magnetic field. [m_{proton} = 1.67 x 10^{-27} kg, q_{proton} = 1.6 x 10^{-19}C]

10. Of the following, which is the best estimate of the work done by the magnetic field on the protons during one complete orbit of the circle?
A. 0 J B. 10^{-22} J C. 10^{-5} J D. 10^{2} J E. 10^{20} J

11. Of the following, which is the best estimate of the speed of a proton in the beam as it moves in the circle?
A. 10^{6} m/s B. 10^{5} m/s C. 10^{4} m/s D. 10^{2} m/s E. 10^{-2} m/s



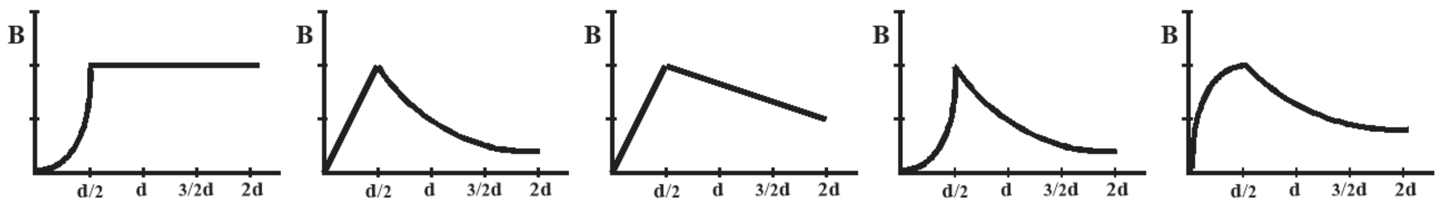
A very long wire oriented perpendicularly to the paper has a diameter d and has a current I flowing uniformly out of the page.

12. What will be the magnitude of the magnetic field within the wire as a function of the distance r from the center of the wire?

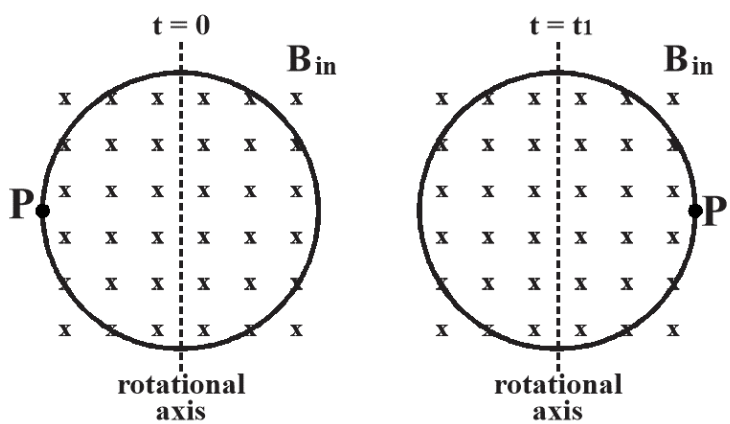
A. $\frac{6\mu_o Ir}{5\pi d^3}$ B. $\frac{3\mu_o Ir^2}{2\pi d^2}$ C. $\frac{4\mu_o Ir}{\pi d^2}$ D. $\frac{2\mu_o Ir}{\pi d^2}$ E. $\frac{4\mu_o Ir^2}{\pi d^2}$

13. Which of the following graphs best shows the magnetic field as a function of distance from the center of the wire?

A. B. C. D. E.

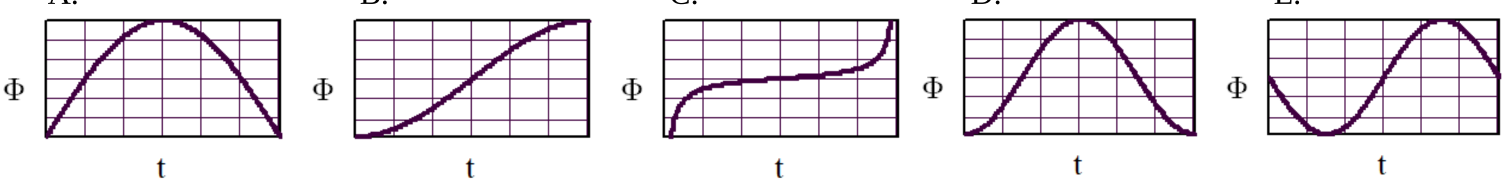


A circular loop of wire in a uniform magnetic field B_{in} rotates at a constant rotational speed about the axis shown. At time t = 0 the plane of the loop is perpendicular to the field with point P at the left as shown. At time t = t_1 the loop has been rotated 180° so that point P is at the right as shown. [Assume out of the page is positive.]

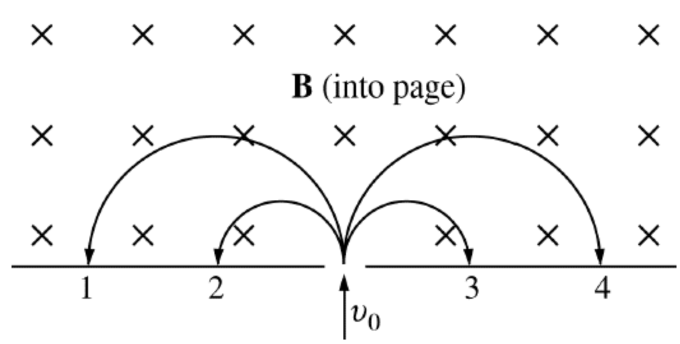


14. Which of the following graphs best represents the magnetic flux Φ through the loop as a function of time t from 0 to t_1?

A. B. C. D. E.



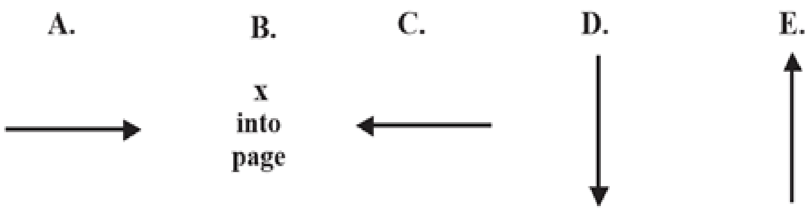
15. Two particles with the same speed v_o enter a region of uniform magnetic field B directed into the page and are initially traveling perpendicular to B, as shown above. Particle Y has charge positive Q and mass 2M; particle Z has charge negative 2Q and mass 2M. Which of the following pairs of paths shown is possible for the subsequent motion of the particles?

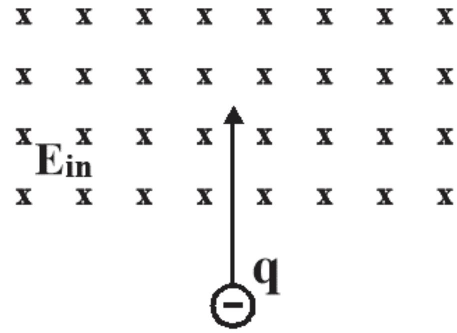


	Particle Y	Particle Z
A.	1	4
B.	1	3
C.	3	1
D.	4	1
E.	4	2

A negatively charged particle q = -10 μC enters an area of space where there is an electric field E_{in} = 20,000 N/C directed into the paper as shown with a speed of v = 5.0 x 10^5 m/s.

16. Which of the following vectors shows the direction of a magnetic field B that could be added so that this negative particle would follow a straight path through the field?

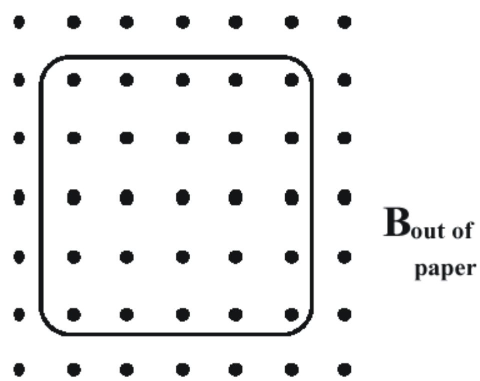




17. What is the magnitude of the magnetic field B required in order for this charged particle to pass through the electric field undeflected?
A. 0.20 T B. 0.020 T C. 0.80 T D. 1.20 T E. 0.040 T

---

18. A square coil of wire of side 0.50 meters, 32 turns, and a resistance 6.0 Ω is located in a uniform magnetic field of intensity B_o = 2.0 Tesla initially directed out of the page as shown. The magnetic field then changes at a constant rate to a new magnetic field of B_f = 4.0 Tesla directed into the page at the end of 0.40 seconds. As the field changes, what are the magnitude and direction of the current in the coil?
A. 5 A, clockwise
B. 10 A, clockwise
C. 20 A, counterclockwise
D. 20 A, clockwise
E. 10 A, counterclockwise

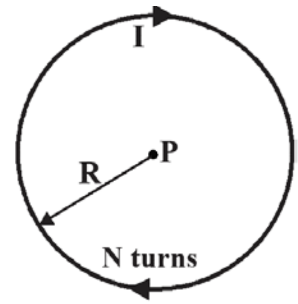


19. Which of the following mathematical expressions implies that all magnetic field lines close on themselves?
A. $\oint E dA = \frac{q}{\varepsilon_o}$ B. $\int B dl = \mu_o \cdot I$ C. $\oint B dA = 0$ D. $\int E dl = V$ E. $\oint E dA = B$

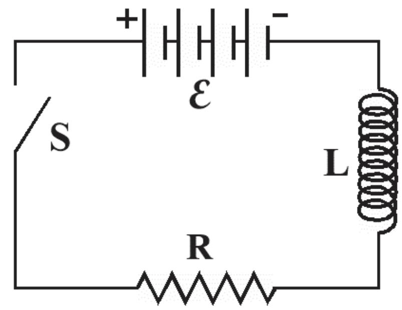
20. The electric field E can be measured in Volts/m while the magnetic field B can be measured in Weber/m^2. What will be the units of the ratio E/B?
A. Tesla/Ampere B. Newton/Ampere C. meter/second D. Joule/Coulomb E. Ampere/Joule

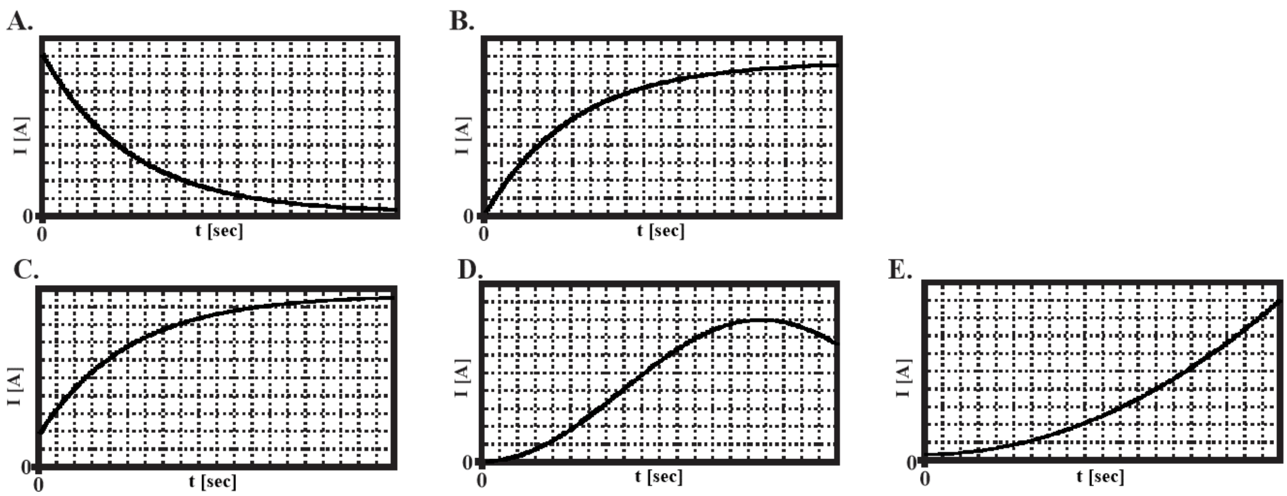
21. A flat coil of wire having a radius of R = 12.0 cm and consisting of N = 100 turns, has a current of 5.0 Amperes flowing clockwise as shown to the right. What will be the magnetic field strength B at point P in the center of the coil?

A. 0.051 T B. 0.510 T C. 0.00013 T D. 0.60 T E. 0.0026 T



22. In the circuit to the right, the switch S is closed at time t=0s. Which of the following graphs correctly shows the current through the resistor as a function of time?





23. The principle difference between ferromagnetic and diamagnetic substances is that ________________ .

A. in ferromagnetic substances, magnetic domains are pointing in alternating opposite directions while in diamagnetic substances, the magnetic domains tend to be aligned in the same direction

B. ferromagnetic substances tend to strengthen an applied external magnetic field while diamagnetic substances tend to weaken an applied external magnetic field

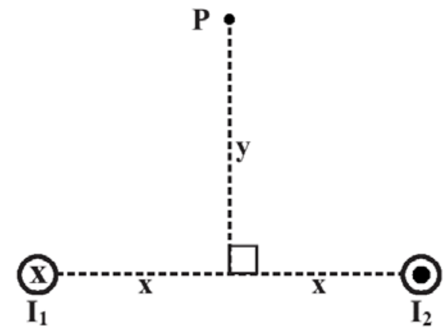
C. ferromagnetic substances weakly attract a magnet while diamagnetic substances strongly repel a magnet

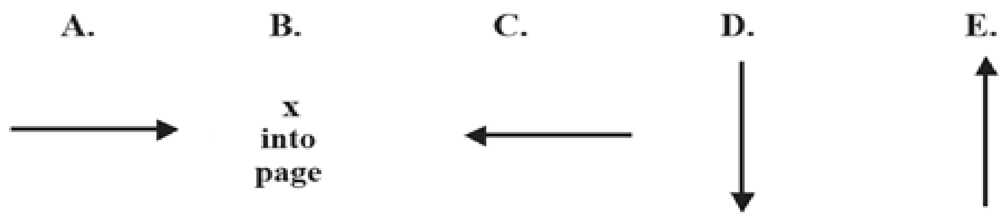
D. ferromagnetic substances tend to weaken an applied external magnetic field while diamagnetic substances tend to strengthen an applied external magnetic field

E. as long as the temperature is below the Curie temperature, both ferromagnetic and diamagnetic substances react to an external magnetic field in similar ways

In the diagram to the right, two currents of equal magnitude
$I_1 = I_2$ are flowing in opposite directions as shown.

24. Which of the following vectors point in the direction of the net magnetic field at point P?





25. What would be the magnitude of the magnetic force acting on an alpha particle [+2e] at point P moving in the positive y direction with a velocity v?

A. $2e \cdot v \cdot \frac{I_1 \cdot \mu_o}{\pi \cdot (x^2 + y^2)}$

B. $e \cdot v \cdot \frac{I_1 \cdot \mu_o \cdot x}{2\pi \cdot (x^2 + y^2)}$

C. $2e \cdot v \cdot \frac{I_1 \cdot \mu_o \cdot x}{\pi \cdot \sqrt{x^2 + y^2}}$

D. $2e \cdot v \cdot \frac{I_1 \cdot \mu_o \cdot y}{\pi \cdot (x^2 + y^2)}$

E. zero

ADVANCED PLACEMENT PHYSICS C EQUATIONS updated 12-20-2017

MECHANICS

$v_x = v_{x0} + a_x t$

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

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

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

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

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

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

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

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

$K = \frac{1}{2} m v^2$

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

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

$\Delta U_g = mg\Delta h$

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

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

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

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

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

$v = r\omega$

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

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

$\omega = \omega_0 + \alpha t$

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

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

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

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

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

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

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

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

$\left|\vec{F}_G\right| = \frac{G m_1 m_2}{r^2}$

$U_G = -\frac{G m_1 m_2}{r}$

ELECTRICITY AND MAGNETISM

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

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

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

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

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

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

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

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

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

$C_p = \sum_i C_i$

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

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

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

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

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

$I = N e v_d A$

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

$R_s = \sum_i R_i$

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

$P = I\Delta V$

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

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

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

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

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

$B_s = \mu_0 n I$

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

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

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

$U_L = \frac{1}{2} L I^2$

ADVANCED PLACEMENT PHYSICS C EQUATIONS

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

$V = \pi r^2 \ell$

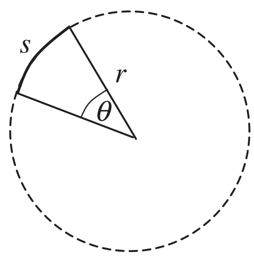
$S = 2\pi r \ell + 2\pi r^2$

Sphere

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

$S = 4\pi r^2$

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



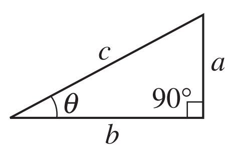
Right Triangle

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

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

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

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



CALCULUS

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

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

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

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

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

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

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

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

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

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

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

VECTOR PRODUCTS

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

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

Physics C Answer Key: **Orchid Test**
Date April 12, 2018 Corrections:

All schools and areas must finish the April exam and post mark or scan all results by April 30th..

1	E	6	E	11	B	16	C	21	E
2	A	7	E & A	12	D	17	E	22	B
3	E	8	D	13	B	18	C	23	B
4	E	9	C	14	B	19	C	24	D
5	D	10	A	15	B	20	C	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 2018 Season

Thursday April 12, 2018

All schools and areas must finish the April exam and post mark or scan all results by April 30th.

New Jersey Science League
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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 for 2019 Season

Thursday January 10, 2019 Thursday February 14, 2019
Thursday March 14, 2019 Thursday April 11, 2019