# Practice Test 1

**PHYSICS C**

Physics C has two exams: Physics C (Mechanics) and Physics C (Electricity and Magnetism):

| | Physics C (Mechanics) | Physics C (Electricity and Magnetism) |
|---|---|---|
| First 45 min. | Sec. I, Multiple Choice<br>35 questions | Sec. I, Multiple Choice<br>35 questions |
| Second 45 min. | Sec. II, Free Response<br>3 questions | Sec. II, Free Response<br>3 questions |

You may take just Mechanics or just Electricity and Magnetism, or both. If you take both, you will receive a separate grade for each. Each section of each examination is 50 percent of the total grade; each question in a section has equal weight. Calculators are permitted on both sections of the exam. However, calculators cannot be shared with other students and calculators with typewriter-style (QWERTY) keyboards will not be permitted. On the following pages you will find the Table of Information that is provided to you during the exam.

**If you are taking**
**— *Mechanics only*, please be careful to answer numbers 1–35;**
**— *Electricity and Magnetism only*, please be careful to answer numbers 36–70;**
**— *the entire examination* (Mechanics *and* Electricity and Magnetism), answer numbers 1–70 on your answer sheet.**

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# ADVANCED PLACEMENT PHYSICS C TABLE OF INFORMATION

| CONSTANTS AND CONVERSION FACTORS | | | |
|---|---|---|---|
| Proton mass, | $m_p = 1.67 \times 10^{-27}$ kg | Electron charge magnitude, | $e = 1.60 \times 10^{-19}$ C |
| Neutron mass, | $m_n = 1.67 \times 10^{-27}$ kg | 1 electron volt, | 1 eV $= 1.60 \times 10^{-19}$ J |
| Electron mass, | $m_e = 9.11 \times 10^{-31}$ kg | Speed of light, | $c = 3.00 \times 10^8$ m/s |
| Avogadro's number, | $N_A = 6.02 \times 10^{23}$ mol$^{-1}$ | Universal gravitational constant, | $G = 6.67 \times 10^{-11}$ (N•m$^2$)/kg$^2$ |
| Universal gas constant, | $R = 8.31$ J/(mol K) | Acceleration due to gravity at Earth's surface, | $g = 9.8$ m/s$^2$ |
| Boltzmann's constant, | $k_B = 1.38 \times 10^{-23}$ J/K | | |

| | |
|---|---|
| 1 unified atomic mass unit, | 1 u $= 1.66 \times 10^{-27}$ kg $= 931$ MeV/$c^2$ |
| Planck's constant, | $h = 6.63 \times 10^{-34}$ J•s $= 4.14 \times 10^{-15}$ eV•s |
| | $hc = 1.99 \times 10^{-25}$ J•m $= 1.24 \times 10^3$ eV•nm |
| Vacuum permittivity, | $\varepsilon_0 = 8.85 \times 10^{-12}$ C$^2$/(N•m$^2$) |
| Coulomb's law constant, | $k = 1/(4\pi\varepsilon_0) = 9.0 \times 10^9$ (N•m$^2$)/C$^2$ |
| Vacuum permeability, | $\mu_0 = 4\pi \times 10^{-7}$ (T•m)/A |
| Magnetic constant, | $k' = \mu_0/(4\pi) = 1 \times 10^{-7}$ (T•m)/A |
| 1 atmosphere pressure, | 1 atm $= 1.0 \times 10^5$ N/m$^2$ $= 1.0 \times 10^5$ Pa |

| UNIT SYMBOLS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | meter, | m | mole, | mol | watt, | W | farad, | F |
| | kilogram, | kg | hertz, | Hz | coulomb, | C | tesla, | T |
| | second, | s | newton, | N | volt, | V | degree Celsius, | °C |
| | ampere, | A | pascal, | Pa | ohm, | Ω | electron volt, | eV |
| | kelvin, | K | joule, | J | henry, | H | | |

| VALUES OF TRIGONOMETRIC FUNCTIONS FOR COMMON ANGLES | | | | | | | |
|---|---|---|---|---|---|---|---|
| $\theta$ | 0° | 30° | 37° | 45° | 53° | 60° | 90° |
| $\sin\theta$ | 0 | 1/2 | 3/5 | $\sqrt{2}/2$ | 4/5 | $\sqrt{3}/2$ | 1 |
| $\cos\theta$ | 1 | $\sqrt{3}/2$ | 4/5 | $\sqrt{2}/2$ | 3/5 | 1/2 | 0 |
| $\tan\theta$ | 0 | $\sqrt{3}/3$ | 3/4 | 1 | 4/3 | $\sqrt{3}$ | $\infty$ |

| PREFIXES | | |
|---|---|---|
| Factor | Prefix | Symbol |
| $10^9$ | giga | G |
| $10^6$ | mega | M |
| $10^3$ | kilo | k |
| $10^{-2}$ | centi | c |
| $10^{-3}$ | milli | m |
| $10^{-6}$ | micro | μ |
| $10^{-9}$ | nano | n |
| $10^{-12}$ | pico | p |

The following assumptions are used in this exam.

I. The frame of reference of any problem is inertial unless otherwise stated.

II. The direction of current is the direction in which positive charges would drift.

III. The electric potential is zero at an infinite distance from an isolated point charge.

IV. All batteries and meters are ideal unless otherwise stated.

V. Edge effects for the electric field of a parallel plate capacitor are negligible unless otherwise stated.

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| MECHANICS | | ELECTRICITY AND MAGNETISM | |
|---|---|---|---|
| $v_x = v_{x0} + a_x t$ | $a$ = acceleration | $\left\lvert\vec{F}_E\right\rvert = \frac{1}{4\pi\varepsilon_0}\left\lvert\frac{q_1 q_2}{r^2}\right\rvert$ | $A$ = area |
| $x = x_0 + v_{x0}t + \frac{1}{2}a_x t^2$ | $E$ = energy | $\vec{E} = \frac{\vec{F}_E}{q}$ | $B$ = magnetic field |
| $v_x^2 = v_{x0}{}^2 + 2a_x(x - x_0)$ | $F$ = force | $\oint \vec{E}\cdot d\vec{A} = \frac{Q}{\varepsilon_0}$ | $C$ = capacitance |
| $\vec{a} = \frac{\Sigma\vec{F}}{m} = \frac{\vec{F}_{net}}{m}$ | $f$ = frequency | $E_x = -\frac{dV}{dx}$ | $d$ = distance |
| $\vec{F} = \frac{d\vec{p}}{dt}$ | $h$ = height | $\Delta V = -\int \vec{E}\cdot\vec{dr}$ | $E$ = electric field |
| $\vec{J} = \int \vec{F}\,dt = \Delta\vec{p}$ | $I$ = rotational inertia | $V = \frac{1}{4\pi\varepsilon_0}\sum_i \frac{q_i}{r_i}$ | $\varepsilon$ = emf |
| $\vec{p} = m\vec{v}$ | $J$ = impulse | $U_E = qV = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r}$ | $F$ = force |
| $\left\lvert\vec{F}_f\right\rvert \le \mu \left\lvert\vec{F}_N\right\rvert$ | $K$ = kinetic energy | $\Delta V = \frac{Q}{C}$ | $I$ = current |
| $\Delta E = W = \int \vec{F}\cdot d\vec{r}$ | $k$ = spring constant | $C = \frac{\kappa\varepsilon_0 A}{d}$ | $J$ = current density |
| $K = \frac{1}{2}mv^2$ | $\ell$ = length | $C_p = \sum_i C_i$ | $L$ = inductance |
| $P = \frac{dE}{dt}$ | $L$ = angular momentum | $\frac{1}{C_s} = \sum_i \frac{1}{C_i}$ | $\ell$ = length |
| $P = \vec{F}\cdot\vec{v}$ | $m$ = mass | $I = \frac{dQ}{dt}$ | $n$ = number of loops of wire per unit length |
| $\Delta U_g = mg\Delta h$ | $P$ = power | $U_C = \frac{1}{2}Q\Delta V = \frac{1}{2}C(\Delta V)^2$ | $N$ = number of charge carriers per unit volume |
| $a_c = \frac{v^2}{r} = \omega^2 r$ | $p$ = momentum | $R = \frac{\rho\ell}{A}$ | $P$ = power |
| $\vec{\tau} = \vec{r}\times\vec{F}$ | $r$ = radius or distance | $\vec{E} = \rho\vec{J}$ | $Q$ = charge |
| $\vec{\alpha} = \frac{\Sigma\vec{\tau}}{I} = \frac{\vec{\tau}_{net}}{I}$ | $T$ = period | $I = Nev_d A$ | $q$ = point charge |
| $I = \int r^2 dm = \Sigma mr^2$ | $t$ = time | $I = \frac{\Delta V}{R}$ | $R$ = resistance |
| $x_{cm} = \frac{\Sigma m_i x_i}{\Sigma m_i}$ | $U$ = potential energy | $R_s = \sum_i R_i$ | $r$ = radius or distance |
| $v = r\omega$ | $v$ = velocity or speed | $\frac{1}{R_p} = \sum_i \frac{1}{R_i}$ | $t$ = time |
| $\vec{L} = \vec{r}\times\vec{p} = I\vec{\omega}$ | $W$ = work done on a system | $P = I\Delta V$ | $U$ = potential or stored energy |
| $K = \frac{1}{2}I\omega^2$ | $x$ = position | | $V$ = electric potential |
| $\omega = \omega_0 + \alpha t$ | $\mu$ = coefficient of friction | | $v$ = velocity or speed |
| $\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$ | $\theta$ = angle | | $\rho$ = resistivity |
| | $\tau$ = torque | | $\Phi$ = flux |
| | $\omega$ = angular speed | | $\kappa$ = dielectric constant |
| | $\alpha$ = angular acceleration | | $\vec{F}_M = q\vec{v}\times\vec{B}$ |
| | $\phi$ = phase angle | | $\oint \vec{B}\cdot d\vec{\ell} = \mu_0 I$ |
| | $\vec{F}_S = -k\Delta\vec{x}$ | | $d\vec{B} = \frac{\mu_0}{4\pi}\frac{I d\vec{\ell}\times\vec{r}}{r^2}$ |
| | $U_S = \frac{1}{2}k(\Delta x)^2$ | | $\vec{F} = \int I d\vec{\ell}\times\vec{B}$ |
| | $x = x_{max}\cos(\omega t + \phi)$ | | $B_S = \mu_0 nI$ |
| | $T = \frac{2\pi}{\omega} = \frac{1}{f}$ | | $\Phi_B = \int \vec{B}\cdot d\vec{A}$ |
| | $T_S = 2\pi\sqrt{\frac{m}{k}}$ | | $\varepsilon = \oint \vec{E}\cdot d\vec{\ell} = -\frac{d\Phi_B}{dt}$ |
| | $T_P = 2\pi\sqrt{\frac{\ell}{g}}$ | | $\varepsilon = -L\frac{dI}{dt}$ |
| | $\left\lvert\vec{F}_G\right\rvert = \frac{Gm_1 m_2}{r^2}$ | | $U_L = \frac{1}{2}LI^2$ |
| | $U_G = -\frac{Gm_1 m_2}{r}$ | | |

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## 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**

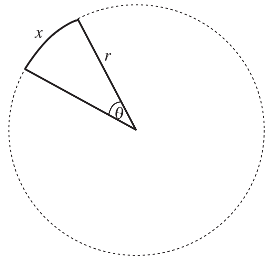
$a^2 + b^2 = c^2$

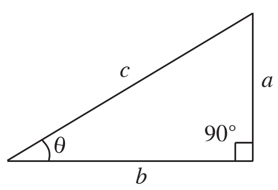
$\sin\theta = \frac{a}{c}$

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

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

$A$ = area
$C$ = circumference
$V$ = volume
$S$ = surface area
$b$ = base
$h$ = height
$\ell$ = length
$w$ = width
$r$ = radius
$s$ = arc length
$\theta$ = angle




## CALCULUS

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

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

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

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

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

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

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

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

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

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

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

**VECTOR PRODUCTS**

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

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

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# PHYSICS C: MECHANICS
## SECTION I
**Time—45 minutes**
**35 Questions**

**Directions:** Each of the questions or incomplete statements below is followed by five suggested answers or completions. Select the one that is best in each case and then mark it on your answer sheet.

1. A rock is dropped off a cliff and falls the first half of the distance to the ground in $t_1$ seconds. If it falls the second half of the distance in $t_2$ seconds, what is the value of $t_2/t_1$? (Ignore air resistance.)

(A) $1/(2\sqrt{2})$
(B) $1/\sqrt{2}$
(C) 1/2
(D) $1-(1/\sqrt{2})$
(E) $\sqrt{2}-1$

2. A bubble starting at the bottom of a soda bottle experiences constant acceleration, $a$, as it rises to the top of the bottle in some time, $t$. How much farther does it travel in the last second of its journey than in the first second? Assume that the journey takes longer than 2 seconds.

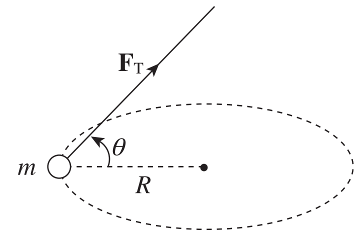
(A) $a(t + 1\text{ s})^2$
(B) $a(t - 1\text{ s})^2$
(C) $at^2$
(D) $a(t + 1\text{ s})(1\text{ s})$
(E) $a(t - 1\text{ s})(1\text{ s})$

3. An object initially at rest experiences a time-varying acceleration given by $a = (2\text{ m/s}^3)t$ for $t \geq 0$. How far does the object travel in the first 3 seconds?

(A) 9 m
(B) 12 m
(C) 18 m
(D) 24 m
(E) 27 m

4. What is the benefit of raising an object using an inclined plane instead of simply lifting the object? Assume ideal conditions.

(A) The amount of force needed to move the object is reduced.
(B) The amount of time needed to move the object is reduced.
(C) The distance the object must be moved is reduced.
(D) The amount of work needed to move the object is reduced.
(E) The power that must be exerted will be reduced.




5. In the figure shown, a tension force $\mathbf{F}_T$ causes a particle of mass $m$ to move with constant angular speed ω in a horizontal circular path (in a plane perpendicular to the page) of radius $R$. Which of the following expressions gives the magnitude of $\mathbf{F}_T$? (Ignore air resistance.)

(A) $m\omega^2 R$
(B) $m\sqrt{\omega^4 R^2 - g^2}$
(C) $m\sqrt{\omega^4 R^2 + g^2}$
(D) $m(\omega^2 R - g)$
(E) $m(\omega^2 R + g)$

6. An object (mass = $m$) above the surface of the Moon (mass = $M$) is dropped from an altitude $h$ equal to the Moon's radius ($R$). With what speed will the object strike the lunar surface?

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

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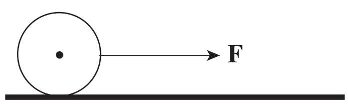
7. Two pendulums are constructed in such a way that they are identical except that one has a hanging mass of $m$ and the other has a hanging mass of $2m$. Both hanging masses are set into motion such that each system has the same total mechanical energy. Assume that the motion approximates simple harmonic motion. Comparatively, the system with the lesser mass will have greater

(A) maximum speed and maximum angle of displacement
(B) frequency and maximum angle of displacement
(C) period and maximum speed
(D) frequency only
(E) maximum angle of displacement only

8. A uniform cylinder of mass $m$ and radius $r$ unrolls without slipping from two strings tied to a vertical support. If the rotational inertia of the cylinder is $\frac{1}{2}mr^2$, find the acceleration of its center of mass.

(A) $\frac{1}{4}g$
(B) $\frac{1}{2}g$
(C) $\frac{1}{3}g$
(D) $\frac{2}{3}g$
(E) $\frac{3}{4}g$

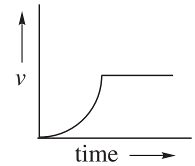



9. A space shuttle is launched from Earth. As it travels up, it moves at a constant velocity of 150 m/s straight up. If its engines provide $1.5 \times 10^8$ W of power, what is the shuttle's mass? You may assume that the shuttle's mass and the acceleration due to gravity are constant.

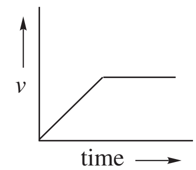
(A) $6.7 \times 10^2$ kg
(B) $1.0 \times 10^5$ kg
(C) $6.7 \times 10^5$ kg
(D) $1.0 \times 10^6$ kg
(E) $2.3 \times 10^6$ kg

10. A uniform cylinder, initially at rest on a frictionless, horizontal surface, is pulled by a constant force **F** from time $t = 0$ to time $t = T$. From time $t = T$ on, this force is removed. Which of the following graphs best illustrates the speed, $v$, of the cylinder's center of mass from $t = 0$ to $t = 2T$?

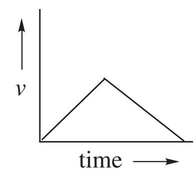
(A)



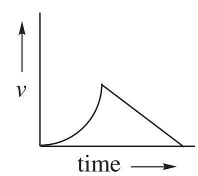

(B)



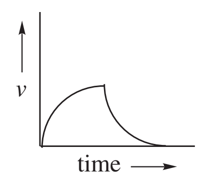

(C)




(D)




(E)

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11. A satellite is in circular orbit around Earth. If the work required to lift the satellite to its orbital height is equal to the satellite's kinetic energy while in this orbit, how high above the surface of Earth (radius = $R$) is the satellite?

(A) $\frac{1}{2}R$
(B) $\frac{2}{3}R$
(C) $R$
(D) $\frac{3}{2}R$
(E) $2R$

12. A block of length $\ell_1$ = 10 cm, mass $m_1$ = 10 kg, and $v_1$ = 2 m/s is currently moving toward a second block. The second block has length $\ell_2$ = 20 cm, $m_2$ = 2 kg, and $v_2$ = 8 m/s and is moving toward the first block. The blocks' closest edges are currently 1 m apart. The blocks will experience a perfectly inelastic collision. How long after the collision does it take for the center of mass of the new object to cross the point midway between the blocks' starting positions? Assume the mass of each block is uniformly distributed.

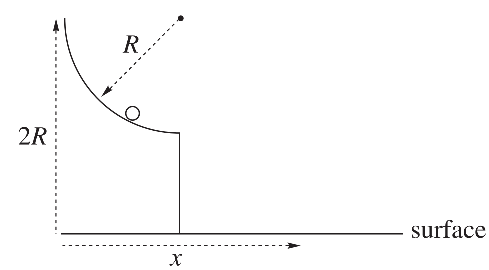
(A) 0.225 s
(B) 0.325 s
(C) 0.525 s
(D) 0.900 s
(E) 0.975 s

13. A rubber ball (mass = 0.08 kg) is dropped from a height of 3.2 m and, after bouncing off the floor, rises almost to its original height. If the impact time with the floor is measured to be 0.04 s, what average force did the floor exert on the ball?

(A) 0.16 N
(B) 16 N
(C) 32 N
(D) 36 N
(E) 64 N

14. A disk of radius 0.1 m initially at rest undergoes an angular acceleration of 2.0 rad/s$^2$. If the disk only rotates, find the total distance traveled by a point on the rim of the disk in 4.0 s.

(A) 0.4 m
(B) 0.8 m
(C) 1.2 m
(D) 1.6 m
(E) 2.0 m




15. In the figure above, a small object slides down a frictionless quarter-circular slide of radius $R$. If the object starts from rest at a height equal to $2R$ above a horizontal surface, find its horizontal displacement, $x$, at the moment it strikes the surface.

(A) $2R$
(B) $\frac{5}{2}R$
(C) $3R$
(D) $\frac{7}{2}R$
(E) $4R$

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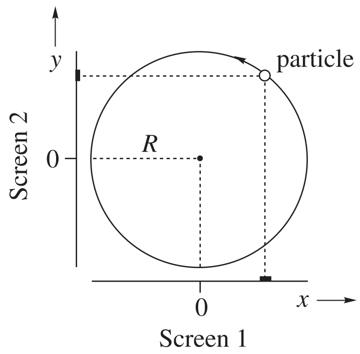
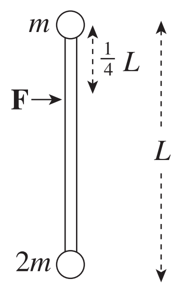



16. The figure above shows a particle executing uniform circular motion in a circle of radius $R$. Light sources (not shown) cause shadows of the particle to be projected onto two mutually perpendicular screens. The positive directions for $x$ and $y$ along the screens are denoted by the arrows. When the shadow on Screen 1 is at position $x = -(0.5)R$ and moving in the $+x$ direction, what is true about the position and velocity of the shadow on Screen 2 at that same instant?

(A) $y = -(0.866)R$; velocity in $-y$ direction
(B) $y = -(0.866)R$; velocity in $+y$ direction
(C) $y = -(0.5)R$; velocity in $-y$ direction
(D) $y = +(0.866)R$; velocity in $-y$ direction
(E) $y = +(0.866)R$; velocity in $+y$ direction




17. The figure shows a view from above of two objects attached to the end of a rigid massless rod at rest on a frictionless table. When a force **F** is applied as shown, the resulting rotational acceleration of the rod about its center of mass is $kF/(mL)$. What is $k$?

(A) $\frac{3}{8}$

(B) $\frac{1}{2}$

(C) $\frac{5}{8}$

(D) $\frac{3}{4}$

(E) $\frac{5}{6}$

18. Old cars were made with rigid frames that could retain their shape in a collision. Modern cars are made with frames that crumple in a collision. If each type of vehicle were to crash into a wall and come to a complete stop, which of the following would NOT be true regarding those collisions? Assume the vehicles were of equal mass and traveling at the same speed before the collision.

(A) The modern vehicle would experience less force.
(B) The modern vehicle would experience less impulse.
(C) The modern vehicle's magnitude of acceleration would be less.
(D) The modern vehicle's collision would take less time.
(E) More than one of the above would not be true.

19. A homogeneous bar is lying on a flat table. Besides the gravitational and normal forces (which cancel), the bar is acted upon by exactly two other external forces, $\mathbf{F}_1$ and $\mathbf{F}_2$, which are parallel to the surface of the table. If the net force on the rod is zero, which one of the following is also true?

(A) The net torque on the bar must also be zero.
(B) The bar cannot accelerate translationally or rotationally.
(C) The bar can accelerate translationally if $\mathbf{F}_1$ and $\mathbf{F}_2$ are not applied at the same point.
(D) The net torque will be zero if $\mathbf{F}_1$ and $\mathbf{F}_2$ are applied at the same point.
(E) None of the above

20. An astronaut lands on a planet whose mass and radius are each twice that of Earth. If the astronaut weighs 800 N on Earth, how much will he weigh on this planet?

(A) 200 N
(B) 400 N
(C) 800 N
(D) 1,600 N
(E) 3,200 N

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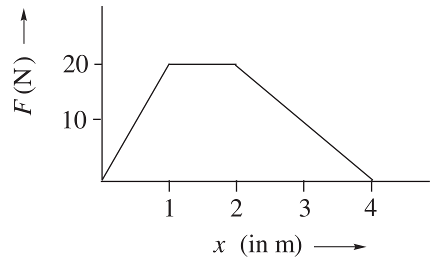
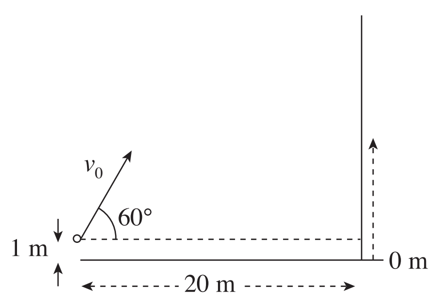



21. A particle of mass $m = 1.0$ kg is acted upon by a variable force, $F(x)$, whose strength is given by the graph above. If the particle's speed was zero at $x = 0$, what is its speed at $x = 4$ m?

(A) 5.0 m/s
(B) 8.7 m/s
(C) 10 m/s
(D) 14 m/s
(E) 20 m/s

22. The radius of a collapsing spinning star (assumed to be a uniform sphere with a constant mass) decreases to $\frac{1}{16}$ of its initial value. What is the ratio of the final rotational kinetic energy to the initial rotational kinetic energy?

(A) 4
(B) 16
(C) $16^2$
(D) $16^3$
(E) $16^4$

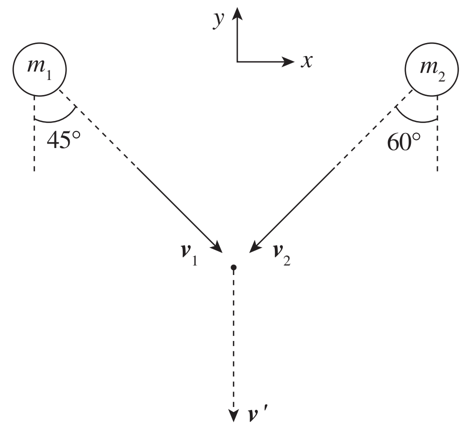



23. A ball is projected with an initial velocity of magnitude $v_0 = 40$ m/s toward a vertical wall as shown in the figure above. How long does the ball take to reach the wall?

(A) 0.25 s
(B) 0.6 s
(C) 1.0 s
(D) 2.0 s
(E) 3.0 s

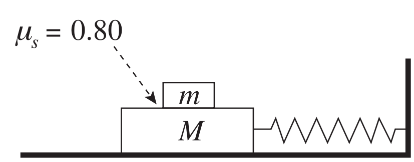
24. If C, M, L, and T represent the dimensions of charge, mass, length, and time respectively, what are the dimensions of the permittivity of free space ($\varepsilon_0$)?

(A) $T^2C^2/(M^2L^2)$
(B) $T^2C^2/(ML^3)$
(C) $ML^3/(T^2C^2)$
(D) $C^2M/(T^2L^2)$
(E) $T^2L^2/(C^2M)$




25. The figure shown above is a view from above of two clay balls moving toward each other on a frictionless surface. They collide perfectly inelastically at the indicated point and are observed to then move in the direction indicated by the post-collision velocity vector, $\boldsymbol{v}'$. If $m_1 = 2m_2$, and $\boldsymbol{v}'$ is parallel to the negative $y$-axis, what is $v_2$?

(A) $v_1(\sin 45°)/(2 \sin 60°)$
(B) $v_1(\cos 45°)/(2 \cos 60°)$
(C) $v_1(2 \cos 45°)/(\cos 60°)$
(D) $v_1(2 \sin 45°)/(\sin 60°)$
(E) $v_1(\cos 45°)/(2 \sin 60°)$



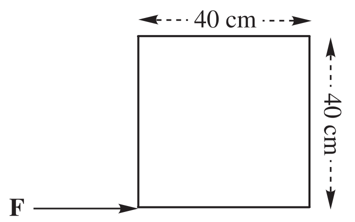

26. In the figure above, the coefficient of static friction between the two blocks is 0.80. If the blocks oscillate with a frequency of 2.0 Hz, what is the maximum amplitude of the oscillations if the small block is not to slip on the large block?

(A) 3.1 cm
(B) 5.0 cm
(C) 6.2 cm
(D) 7.5 cm
(E) 9.4 cm

**GO ON TO THE NEXT PAGE.**

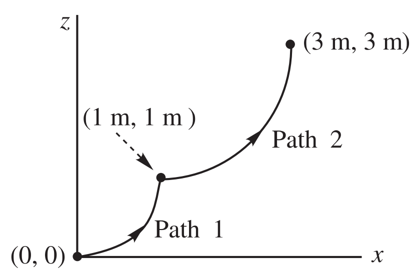
27. When two objects collide, the ratio of the relative speed after the collision to the relative speed before the collision is called the *coefficient of restitution*, *e*. If a ball is dropped from height $H_1$ onto a stationary floor, and the ball rebounds to height $H_2$, what is the coefficient of restitution of the collision?

(A) $H_1/H_2$
(B) $H_2/H_1$
(C) $\sqrt{H_1/H_2}$
(D) $\sqrt{H_2/H_1}$
(E) $(H_1/H_2)^2$




28. The figure above shows a square metal plate of side length 40 cm and uniform density, lying flat on a table. A force **F** of magnitude 10 N is applied at one of the corners, as shown. Determine the torque produced by **F** relative to the center of rotation.

(A) 0 N•m
(B) 1.0 N•m
(C) 1.4 N•m
(D) 2.0 N•m
(E) 4.0 N•m

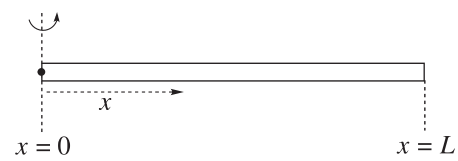



29. A small block of mass $m = 2.0$ kg is pushed from the initial point $(x_i, z_i) = (0 \text{ m}, 0 \text{ m})$ upward to the final point $(x_f, z_f) = (3 \text{ m}, 3 \text{ m})$ along the path indicated. Path 1 is a portion of the parabola $z = x^2$, and Path 2 is a quarter circle whose equation is $(x - 1)^2 + (z - 3)^2 = 4$. How much work is done by gravity during this displacement?

(A) –60 J
(B) –80 J
(C) –90 J
(D) –100 J
(E) –120 J

30. A horizontal spring of spring constant k is experiencing simple harmonic motion between points $x = -A$ and $x = A$ with a block of mass M attached to the end. A bullet of mass m is fired from a gun with speed $v$ so that collides perfectly inelastically with the block when it is at position $x = -A$. How far beyond $x = -A$ will the spring be compressed as a result of this collision?

(A) $mv\sqrt{kM}$
(B) $mv\sqrt{k(M+m)}$
(C) $mv\sqrt{\frac{1}{k(M+m)}}$
(D) $\sqrt{\frac{mv}{k(M+m)}}$
(E) $mv\sqrt{\frac{1}{kM}}$




31. The rod shown above can pivot about the point $x = 0$ and rotates in a plane perpendicular to the page. Its linear density, $\lambda$, increases with $x$ such that $\lambda(x) = kx$, where $k$ is a positive constant. Determine the rod's moment of inertia in terms of its length, $L$, and its total mass, $M$.

(A) $\frac{1}{6}ML^2$
(B) $\frac{1}{4}ML^2$
(C) $\frac{1}{3}ML^2$
(D) $\frac{1}{2}ML^2$
(E) $2ML^2$

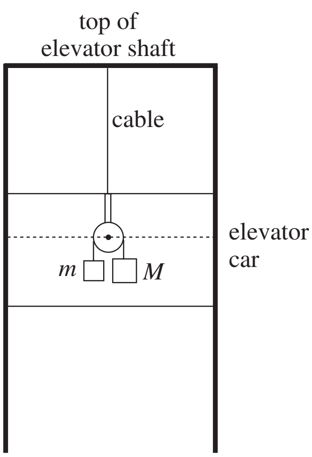
**GO ON TO THE NEXT PAGE.**

32. 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 meters. Which of the following represents a position of stable equilibrium?

(A) $x = -4$
(B) $x = -2$
(C) $x = 0$
(D) $x = 2$
(E) $x = 4$




33. A light, frictionless pulley is suspended from a rigid rod attached to the roof of an elevator car. Two masses, $m$ and $M$ (with $M > m$), are suspended on either side of the pulley by a light, inextendable cord. The elevator car is descending at a constant velocity. Determine the acceleration of the masses.

(A) $(M - m)g$

(B) $(M + m)g$

(C) $\dfrac{M + m}{M - m}g$

(D) $\dfrac{M - m}{M + m}g$

(E) $(M - m)(M + m)g$

34. A block of mass $m = 2$ kg starts at rest at the top of a ramp of angle $\theta_r$ such that $\sin \theta_r = 0.45$ and $\cos \theta_r = 0.9$. The length of the ramp consists of alternating stretches of frictionless portions followed by portions with a coefficient of friction $\mu = \frac{2}{3}$. The first meter of the ramp's length is frictionless, followed by 1 m of friction. The next meter is frictionless again, followed by 2 m of friction. This alternating pattern continues with the frictionless stretch always being 1 m and the friction stretch increasing in length by 1 m each time. How far does the block travel before coming to a stop? Assume the ramp has infinite length.

(A) 4 m
(B) 8 m
(C) 12 m
(D) 19 m
(E) 24 m

35. An object of mass 2 kg is acted upon by three external forces, each of magnitude 4 N. Which of the following could NOT be the resulting acceleration of the object?

(A) 0 m/s$^2$
(B) 2 m/s$^2$
(C) 4 m/s$^2$
(D) 6 m/s$^2$
(E) 8 m/s$^2$

STOP

END OF SECTION I, MECHANICS

# PHYSICS C: MECHANICS

## SECTION II

**Time—45 minutes**

**3 Questions**

**Directions:** Answer all three questions. The suggested time is about 15 minutes per question for answering each of the questions, which are worth 15 points each. The parts within a question may not have equal weight.

1. An ideal projectile is launched from the ground at an angle $\theta$ to the horizontal, with an initial speed of $v_0$. The ground is flat and level everywhere. Write all answers in terms of $v_0$, $\theta$, and fundamental constants.

   (a) Calculate the time the object is in the air.

   (b) Calculate the maximum height the object reaches.

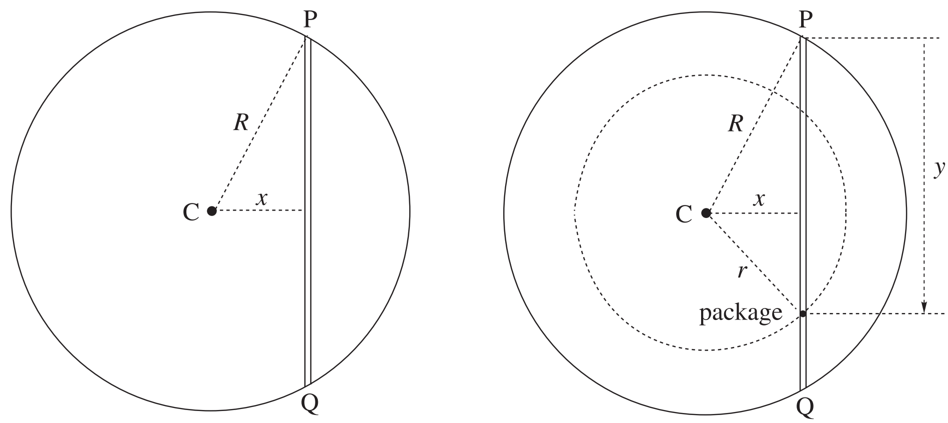
   (c) What is the *net* vertical displacement of the object?

   (d) Calculate the range (horizontal displacement) of the object.

   (e) What should $\theta$ be so that the projectile's range is equal to its maximum vertical displacement?

**GO ON TO THE NEXT PAGE.**

2. A narrow tunnel is drilled through Earth (mass = $M$, radius = $R$), connecting points P and Q, as shown in the diagram on the left below. The perpendicular distance from Earth's center, C, to the tunnel is $x$. A package (mass = $m$) is dropped from Point P into the tunnel; its distance from P is denoted $y$ and its distance from C is denoted $r$. See the diagram on the right.




(a) Assuming that Earth is a homogeneous sphere, the gravitational force $F$ on the package is due to $m$ and the mass contained within the sphere of radius $r < R$. Use this fact to show that

$$F = -\frac{GMm}{R^3}r$$

(b) Use the equation $F(r) = -dU/dr$ to find an expression for the change in gravitational potential energy of the package as it moves from Point P to a point where its distance from Earth's center is $r$. Write your answer in terms of $G$, $M$, $m$, $R$, and $r$.

(c) Apply Conservation of Energy to determine the speed of the package in terms of $G$, $M$, $R$, $x$, and $y$. (Ignore friction.)

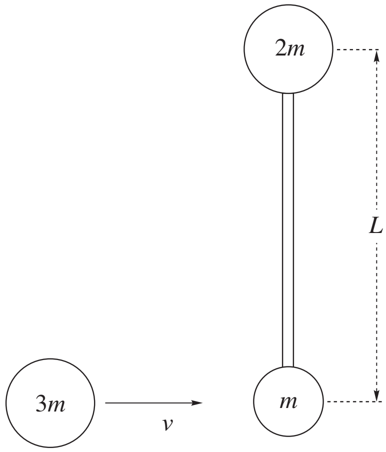
(d)

i. At what point in the tunnel—that is, for what value of $y$—will the speed of the package be maximized?

ii. What is this maximum speed? (Write your answer in terms of G, M, R, and $x$.)

GO ON TO THE NEXT PAGE.

3. The diagram below is a view from above of three sticky hockey pucks on a frictionless horizontal surface. The pucks with masses $m$ and $2m$ are connected by a massless rigid rod of length $L$ and are initially at rest. The puck of mass $3m$ is moving with velocity $\boldsymbol{v}$ directly toward puck $m$. When puck $3m$ strikes puck $m$, the collision is perfectly inelastic.




(a) Immediately after the collision,

i. where is the center of mass of the system?

ii. what is the speed of the center of mass? (Write your answer in terms of $\boldsymbol{v}$.)

iii. what is the angular speed of the system? (Write your answer in terms of $\boldsymbol{v}$ and $L$.)

(b) What fraction of the system's initial kinetic energy is lost as a result of the collision?

STOP

END OF SECTION II, MECHANICS

## PHYSICS C: ELECTRICITY AND MAGNETISM

## SECTION I

**Time—45 minutes**

**35 Questions**

**Directions:** Each of the questions or incomplete statements below is followed by five suggested answers or completions. Select the one that is best in each case and mark it on your answer sheet.

36. A nonconducting sphere is given a nonzero net electric charge, $+Q$, and then brought close to a neutral conducting sphere of the same radius. Which of the following will be true?

(A) An electric field will be induced within the conducting sphere.
(B) The conducting sphere will develop a net electric charge of $-Q$.
(C) The spheres will experience an electrostatic attraction.
(D) The spheres will experience an electrostatic repulsion.
(E) The spheres will experience no electrostatic interaction.

37. If the total resistance of a circuit were doubled, the power dissipated by that same circuit would

(A) increase by a factor of 4
(B) increase by a factor of 2
(C) decrease by a factor of 2
(D) decrease by a factor of 4
(E) Cannot be determined

38. Each of the following ionized isotopes is projected with the same speed into a uniform magnetic field **B** such that the isotope's initial velocity is perpendicular to **B**. Which combination of mass and charge would result in a circular path with the largest radius?

(A) $m = 16\ u$, $q = -5\ e$
(B) $m = 17\ u$, $q = -4\ e$
(C) $m = 18\ u$, $q = -3\ e$
(D) $m = 19\ u$, $q = -2\ e$
(E) $m = 20\ u$, $q = -1\ e$

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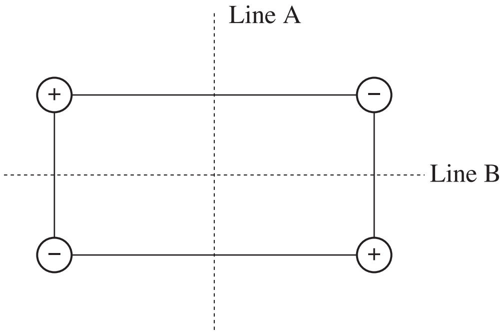



39. The picture above shows 4 charges fixed in position at the corners of a rectangle measuring 2 cm by 4 cm. Assuming the charges are all of equal magnitude, how many locations on either Line A or Line B would be places with 0 net electric field?

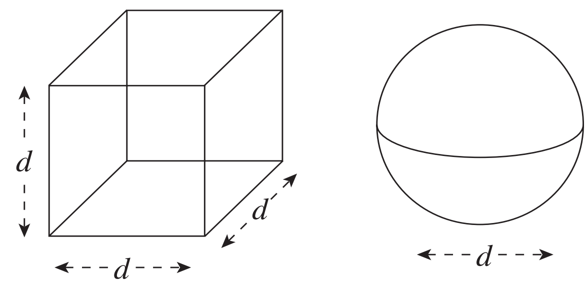
(A) 1
(B) 5
(C) All of Line A
(D) All of Line B
(E) All of both Line A and Line B


40. The four wires shown above are each made of aluminum. Which wire will have the greatest resistance?

(A) Wire A
(B) Wire B
(C) Wire C
(D) Wire D
(E) All the wires have the same resistance because they're all composed of the same material.

41. Which of the following is NOT equal to one tesla?

(A) 1 $J/(A \cdot m^2)$
(B) 1 $kg/(C \cdot s)$
(C) 1 $N/(A \cdot m)$
(D) 1 V $s/m^2$
(E) 1 A N/V




42. The figure above shows two Gaussian surfaces: a cube with side length *d* and a sphere with diameter *d*. The net electric charge enclosed within each surface is the same, $+Q$. If $\Phi_C$ denotes the total electric flux through the cubical surface, and $\Phi_S$ denotes the total electric flux through the spherical surface, then which of the following is true?

(A) $\Phi_C = (\pi/6)\Phi_S$
(B) $\Phi_C = (\pi/3)\Phi_S$
(C) $\Phi_C = \Phi_S$
(D) $\Phi_C = (3/\pi)\Phi_S$
(E) $\Phi_C = (6/\pi)\Phi_S$

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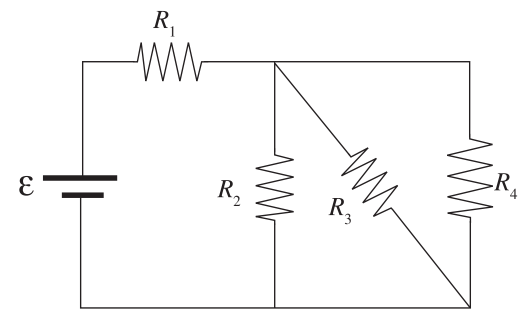
43. The picture above shows two positive charges, $Q_1$ and $Q_2$, of equal magnitude that are fixed in place. If a third positive charge, $q$, were released from rest at the position shown, at what position would it return to rest? Assume ideal conditions and that $Q_1$ occupies the position of $x = 0$ cm and $Q_2$ occupies the position of $x = 1$ cm.
    (A) $x = 30$ cm
    (B) $x = 50$ cm
    (C) $x = 70$ cm
    (D) Cannot be determined without knowing the magnitude of $q$
    (E) It will not stop.

44. An object carries a charge of –1 C. How many excess electrons does it contain?
    (A) $6.25 \times 10^{18}$
    (B) $8.00 \times 10^{18}$
    (C) $1.60 \times 10^{19}$
    (D) $3.20 \times 10^{19}$
    (E) $6.25 \times 10^{19}$

Questions 45-46

Each of the resistors shown in the circuit below has a resistance of 200 Ω. The emf of the ideal battery is 24 V.




45. How much current is provided by the source?
    (A) 30 mA
    (B) 48 mA
    (C) 64 mA
    (D) 72 mA
    (E) 90 mA

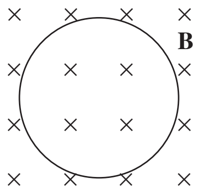
46. What is the ratio of the power dissipated by $R_1$ to the power dissipated by $R_4$?
    (A) 1/9
    (B) 1/4
    (C) 1
    (D) 4
    (E) 9

**GO ON TO THE NEXT PAGE.**

47. What is the value of the following product?

$$20\ \mu F \times 500\ \Omega$$

(A) 0.01 henry
(B) 0.01 ampere per coulomb
(C) 0.01 weber
(D) 0.01 second
(E) 0.01 volt per ampere

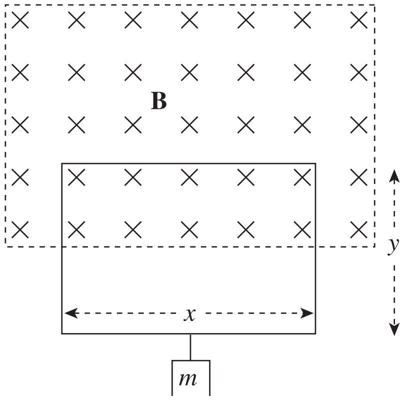



48. A copper wire in the shape of a circle of radius 1 m, lying in the plane of the page, is immersed in a magnetic field, **B**, that points into the plane of the page. The strength of **B** varies with time, $t$, according to the equation

$$B(t) = 2t(1 - t)$$

where $B$ is given in teslas when $t$ is measured in seconds. What is the magnitude of the induced electric field in the wire at time $t = 1$ s?

(A) $(1/\pi)$ N/C
(B) 1 N/C
(C) 2 N/C
(D) $\pi$ N/C
(E) $2\pi$ N/C




49. In the figure above, the top half of a rectangular loop of wire, $x$ meters by $y$ meters, hangs vertically in a uniform magnetic field, **B**. Describe the magnitude and direction of the current in the loop necessary for the magnetic force to balance the weight of the mass $m$ supported by the loop.

(A) $I = mg/xB$, clockwise

(B) $I = mg/xB$, counterclockwise

(C) $I = mg/\left(x + \frac{1}{2}y\right)B$, clockwise

(D) $I = mg/\left(x + \frac{1}{2}y\right)B$, counterclockwise

(E) $I = mg/(x+y)B$, clockwise

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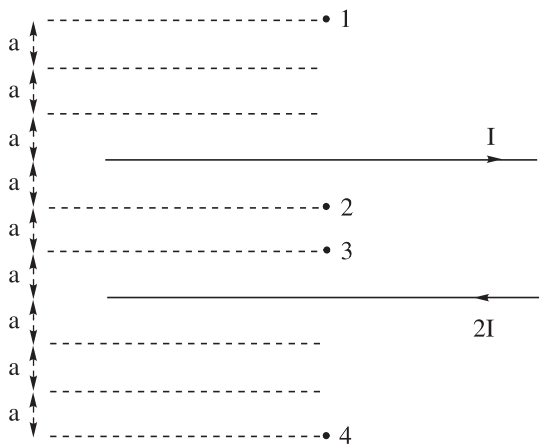
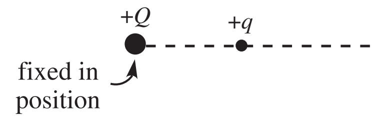
50. A particle with a charge of $q_1 = 10$ nC is held in place. A second particle of charge $q_2 = -5$ nC and mass $m = 5 \times 10^{-10}$ kg is released from rest 2 cm away from the first particle. How fast will it be moving when it is 1 cm away from the first particle?

(A) 100 m/s
(B) 200 m/s
(C) 300 m/s
(D) 400 m/s
(E) 500 m/s



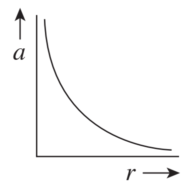

51. The figure above shows a pair of long, straight current-carrying wires and four marked points. At which of these points is the net magnetic field zero?

(A) Point 1 only
(B) Points 1 and 2 only
(C) Point 2 only
(D) Points 3 and 4 only
(E) Point 3 only

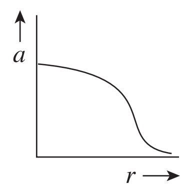



52. The figure above shows two positively charged particles. The $+Q$ charge is fixed in position, and the $+q$ charge is brought close to $+Q$ and released from rest. Which of the following graphs best depicts the acceleration of the $+q$ charge as a function of its distance $r$ from $+Q$?

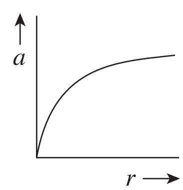
(A)



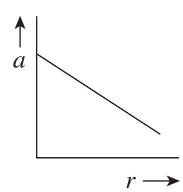

(B)



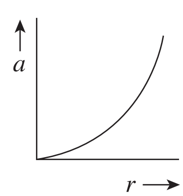

(C)




(D)




(E)

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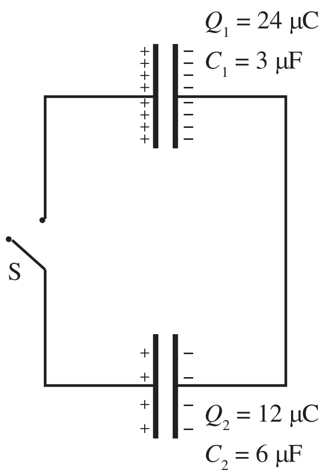
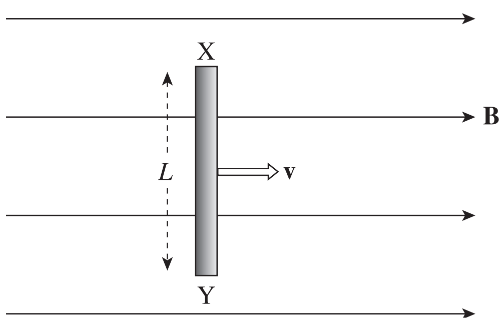



53. Once the switch S in the figure above is closed and electrostatic equilibrium is regained, how much charge will be stored on the positive plate of the 6 μF capacitor?

(A) 9 μC
(B) 18 μC
(C) 24 μC
(D) 27 μC
(E) 36 μC

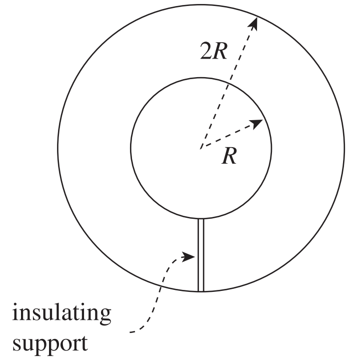



54. A metal bar of length $L$ is pulled with velocity **v** through a uniform magnetic field, **B**, as shown above. What is the voltage produced between the ends of the bar?

(A) $vB$, with Point X at a higher potential than Point Y
(B) $vB$, with Point Y at a higher potential than Point X
(C) $vBL$, with Point X at a higher potential than Point Y
(D) $vBL$, with Point Y at a higher potential than Point X
(E) None of the above

55. An electric dipole consists of a pair of equal but opposite point charges of magnitude 4.0 nC separated by a distance of 2.0 cm. What is the electric field strength at the point midway between the charges?

(A) 0
(B) $9.0 \times 10^4$ V/m
(C) $1.8 \times 10^5$ V/m
(D) $3.6 \times 10^5$ V/m
(E) $7.2 \times 10^5$ V/m




56. The figure above shows a cross section of two concentric spherical metal shells of radii $R$ and $2R$, respectively. Find the capacitance.

(A) $1/(8\pi\varepsilon_0 R)$
(B) $1/(4\pi\varepsilon_0 R)$
(C) $2\pi\varepsilon_0 R$
(D) $4\pi\varepsilon_0 R$
(E) $8\pi\varepsilon_0 R$

57. Traveling at an initial speed of $1.5 \times 10^6$ m/s, a proton enters a region of constant magnetic field, **B**, of magnitude 1.0 T. If the proton's initial velocity vector makes an angle of 30° with the direction of **B**, compute the proton's speed 4 s after entering the magnetic field.

(A) $5.0 \times 10^5$ m/s
(B) $7.5 \times 10^5$ m/s
(C) $1.5 \times 10^6$ m/s
(D) $3.0 \times 10^6$ m/s
(E) $6.0 \times 10^6$ m/s

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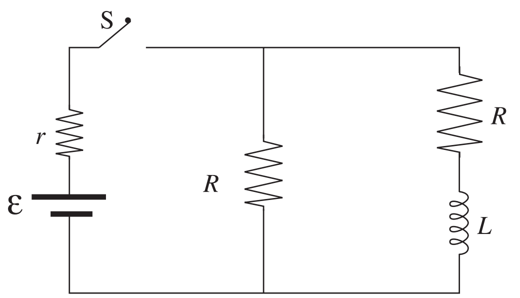
Questions 58-60

There is initially no current through any circuit element in the following diagram.




58. What is the current through $r$ immediately after the switch S is closed?

(A) 0

(B) $\frac{\varepsilon}{r+R}$

(C) $\frac{\varepsilon}{r+2R}$

(D) $\frac{\varepsilon(r+R)}{rR}$

(E) $\frac{\varepsilon(2R)}{2Rr+2R}$

59. After the switch has been kept closed for a long time, how much energy is stored in the inductor?

(A) $\frac{L\varepsilon^2}{2(r+R)^2}$

(B) $\frac{L\varepsilon^2}{2(2r+R)^2}$

(C) $\frac{L\varepsilon^2}{4(2r+R)^2}$

(D) $\frac{L(\varepsilon R)^2}{8(2r+R)^2}$

(E) $\frac{L\varepsilon^2}{8(2r+R)^2}$

60. After having been closed for a long time, the switch is suddenly opened. What is the current through $r$ immediately after S is opened?

(A) 0

(B) $\frac{\varepsilon}{r+R}$

(C) $\frac{\varepsilon}{r+2R}$

(D) $\frac{\varepsilon(r+R)}{rR}$

(E) $\frac{\varepsilon(2R)}{r(2R)+2R}$

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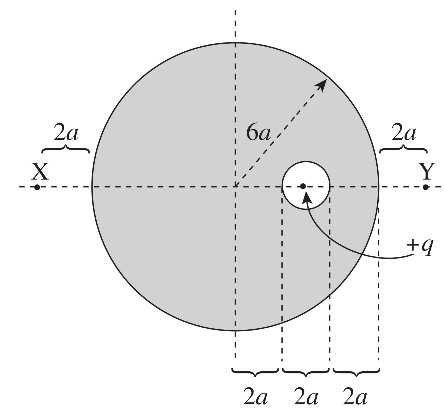


61. A solid, neutral metal sphere of radius $6a$ contains a small cavity, a spherical hole of radius $a$ as shown above. Within this cavity is a charge, $+q$. If $E_X$ and $E_Y$ denote the strength of the electric field at points X and Y, respectively, which of the following is true?

(A) $E_Y = 4E_X$
(B) $E_Y = 16E_X$
(C) $E_Y = E_X$
(D) $E_Y = (11/5)E_X$
(E) $E_Y = (11/5)^2E_X$

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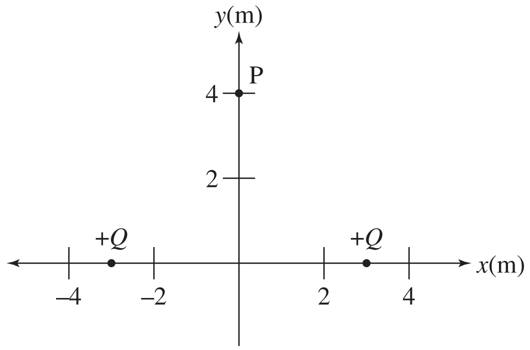



62. Two particles of charge $+Q$ are located on the $x$-axis, as shown above. Determine the work done by the electric field to move a particle of charge $-Q$ from very far away to point P.

(A) $\frac{2kQ}{5}$

(B) $\frac{2kQ^2}{5}$

(C) $-\frac{2kQ^2}{5}$

(D) $\frac{kQ^2}{5}$

(E) $-\frac{3kQ^2}{5}$

63. A battery is connected in a series with a switch, a resistor of resistance $R$, and an inductor of inductance $L$. Initially, there is no current in the circuit. Once the switch is closed and the circuit is completed, how long will it take for the current to reach 99% of its maximum value?

(A) $(\ln \frac{99}{100})RL$

(B) $(\ln 99)RL$

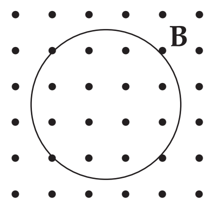
(C) $(\ln \frac{1}{100})\frac{L}{R}$

(D) $\frac{L}{R}(\ln \frac{100}{99})$

(E) $(\ln 100)\frac{L}{R}$

64. What is the maximum number of 40 W light bulbs that could be connected in parallel with a 120 V source? The total current cannot exceed 5 A or the circuit will blow a fuse.

(A) 3
(B) 6
(C) 9
(D) 12
(E) 15




65. The metal loop of wire shown above is situated in a magnetic field **B** pointing out of the plane of the page. If **B** decreases uniformly in strength, the induced electric current within the loop is

(A) clockwise and decreasing
(B) clockwise and increasing
(C) counterclockwise and decreasing
(D) counterclockwise and constant
(E) counterclockwise and increasing

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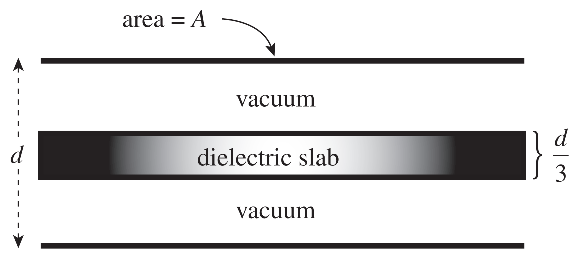



66. A dielectric of thickness $\frac{d}{3}$ is placed between the plates of a parallel-plate capacitor, as shown above. If $K$ is the dielectric constant of the slab, what is the capacitance?

(A) $\dfrac{\varepsilon_0 A(2+3K)}{d}$

(B) $\dfrac{d}{\varepsilon_0 A(2+3K)}$

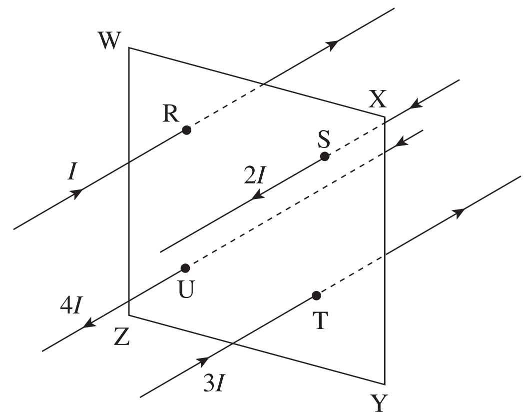
(C) $\dfrac{3\varepsilon_0 A}{d(2K+1)}$

(D) $\dfrac{3K\varepsilon_0 A}{d(2K+1)}$

(E) $\dfrac{3K\varepsilon_0 A}{d}$


67. Consider the two source charges shown above. At how many points in the plane of the page, in a region around these charges are both the electric field and the electric potential equal to zero?

(A) 0
(B) 1
(C) 2
(D) 3
(E) 4




68. The figure above shows four current-carrying wires passing perpendicularly through the interior of a square whose vertices are W, X, Y, and Z. The points where the wires pierce the plane of the square (namely, R, S, T, and U) themselves form the vertices of a square each side of which has half the length of each side of WXYZ. If the currents are as labeled in the figure, what is the absolute value of

$$\oint \mathbf{B} \bullet d\ell$$

where the integral is taken around WXYZ?

(A) $\frac{1}{2}\mu_0 I$
(B) $\mu_0 I$
(C) $\sqrt{2}\,\mu_0 I$
(D) $2\mu_0 I$
(E) $5\mu_0 I$

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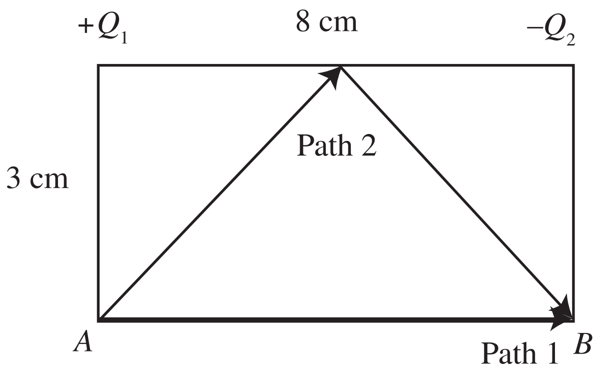



69. A particle with charge $+q$ is moved from point $A$ to point $B$ along path 1 in the picture above. Its change in potential energy is $U$. If a charge of $-q$ is then moved from $A$ to $B$ along path 2, its change in potential energy will be

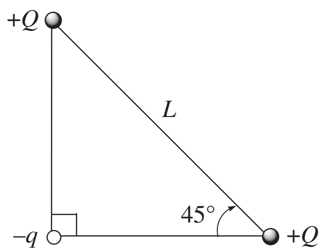
(A) $-\left(\frac{10}{8}\right)U$

(B) $-U$

(C) $U$

(D) $\left(\frac{10}{8}\right)U$

(E) Cannot be determined without knowing the values of $Q_1$ and $Q_2$




70. Two point charges, each $+Q$, are fixed a distance $L$ apart. A particle of charge $-q$ and mass $m$ is placed as shown in the figure above. What is this particle's initial acceleration when released from rest?

(A) $\frac{\sqrt{2}Qq}{2\pi\varepsilon_0 L^2 m}$

(B) $\frac{\sqrt{2}Qq}{\pi\varepsilon_0 L^2 m}$

(C) $\frac{2Qq}{\pi\varepsilon_0 L^2 m}$

(D) $\frac{2\sqrt{2}Qq}{\pi\varepsilon_0 L^2 m}$

(E) $\frac{4Qq}{\pi\varepsilon_0 L^2 m}$

STOP

END OF SECTION I, ELECTRICITY AND MAGNETISM

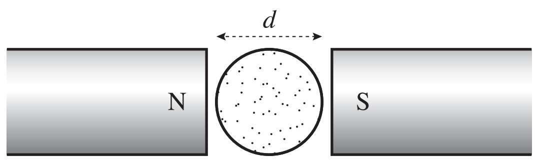
# PHYSICS C: ELECTRICITY AND MAGNETISM

## SECTION II

### Time—45 minutes

### 3 Questions

**Directions:** Answer all three questions. The suggested time is about 15 minutes per question for answering each of the questions, which are worth 15 points each. The parts within a question may not have equal weight.




$\vec{v}$ into plane of the page

1. A stream of equal but oppositely charged particles are moving through a cylinder that is between two magnets as shown above. The magnets create a magnetic field **B** that points from the north pole to the south pole. The particles move with speed $v$, and the cylinder has a diameter $d$.
   (a) The magnetic field will cause the charged particles to move in a way that creates an electric field. Indicate this electric field's direction and qualitatively describe the magnitude of the resulting electric forces on the particles in relation to the magnetic forces the particles experience.
   (b) Assume enough time has passed that a constant potential difference $V$ is established in the cylinder. What is the value of the particles' speed $v$ in terms of the other known values?
   (c) Given that one of the positive particles has a mass of $m$, how much work is done on that particle by the magnetic force in 1 second?
   (d) An overall neutral particle is structured in such a way that it has a slight positive charge on its right side and a slight negative charge on its left side. If this particle were moved through the cylinder, describe the effect the magnetic field would have on such a particle. Ignore any electric forces for this question.

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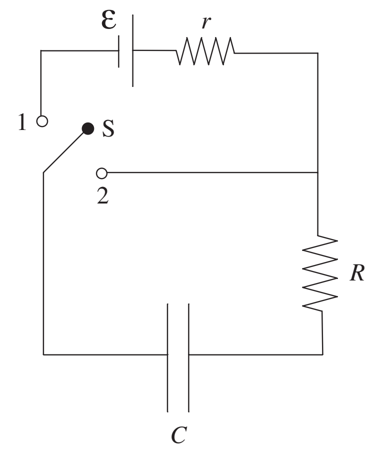
2. In the circuit shown below, the capacitor is initially uncharged and there is no current in any circuit element.




In each of the following, $k$ is a number greater than 1; write each of your answers in terms of $\varepsilon$, $r$, $R$, $C$, $k$, and fundamental constants.

(a) At $t = 0$, the switch S is moved to position 1.

i. At what time $t$ is the current through $R$ equal to $\frac{1}{k}$ of its initial value?

ii. At what time $t$ is the charge on the capacitor equal to $\frac{1}{k}$ of its maximum value?

iii. At what time $t$ is the energy stored in the capacitor equal to $\frac{1}{k}$ of its maximum value?

(b) After the switch has been at position 1 for a very long time, it is then moved to position 2. Let this redefine $t = 0$ for purposes of the following questions.

i. How long will it take for the current through $R$ to equal $\frac{1}{k}$ of its initial value?

ii. At what time $t$ is the charge on the capacitor equal to $\frac{1}{k}$ of its initial value?

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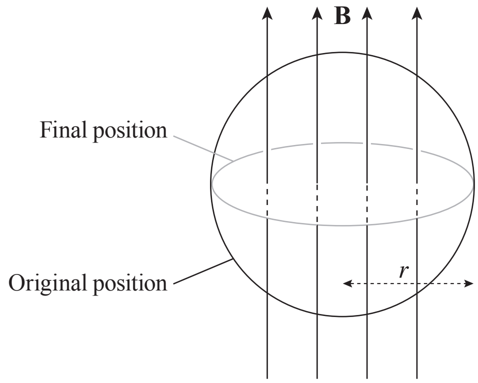


3. The metal ring of radius *r* shown above has a magnetic field of strength *B* passing through it as shown. The ring begins to rotate at a steady angular velocity and continues until it has rotated 90 . It completes the rotation in *T* seconds.
   (a) Find the average induced emf. Express your answer in terms of *B*, *r*, *T*, and fundamental constants.
   (b) During the rotation, what is the direction of the induced current in the ring?
   (c) If the ring has a resistance of R Ω, what is the magnitude of the average induced current? Express your answer in terms of *B*, *r*, *R*, *T*, and fundamental constants.
   (d) If the time at which the maximum instantaneous magnitude of induced emf occurs is given as $t_{max}$, what is the magnitude of that emf? Express your answer in terms of *B*, *r*, *T*, $t_{max}$, and fundamental constants.
   (e) In terms of known values, what would be the value of $t_{max}$ in (d)?

**STOP**

**END OF EXAM**

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Completely darken bubbles with a No. 2 pencil. If you make a mistake, be sure to erase mark completely. Erase all stray marks.

1.

YOUR NAME: ______________________________
(Print) Last First M.I.

SIGNATURE: ______________________________ DATE: ____/____/____

HOME ADDRESS: ______________________________
(Print) Number and Street

______________________________
City State Zip Code

PHONE NO.: ______________________________

IMPORTANT: Please fill in these boxes exactly as shown on the back cover of your test book.

2. TEST FORM

______________________________

3. TEST CODE

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| 2 | C | L | 2 | 2 |
| 3 | D | M | 3 | 3 |
| 4 | E | N | 4 | 4 |
| 5 | F | O | 5 | 5 |
| 6 | G | P | 6 | 6 |
| 7 | H | Q | 7 | 7 |
| 8 | I | R | 8 | 8 |
| 9 | | | 9 | 9 |

4. REGISTRATION NUMBER

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5. YOUR NAME

First 4 letters of last name | FIRST INIT | MID INIT

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

6. DATE OF BIRTH

| Month | Day | | Year | |
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| MAR | 1 | 1 | 1 | 1 |
| APR | 2 | 2 | 2 | 2 |
| MAY | 3 | 3 | 3 | 3 |
| JUN | | 4 | 4 | 4 |
| JUL | | 5 | 5 | 5 |
| AUG | | 6 | 6 | 6 |
| SEP | | 7 | 7 | 7 |
| OCT | | 8 | 8 | 8 |
| NOV | | 9 | 9 | 9 |
| DEC | | | | |

7. GENDER

MALE

FEMALE

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1. A B C D E
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# MECHANICS PRACTICE TEST 1 DIAGNOSTIC

## CHAPTER 4 TEST SCORE SELF-EVALUATION

# WRONG QUESTIONS: ___ / 6 (# TOTAL QUESTIONS) = ___ % YOUR SCORE

## CHAPTER 5 TEST SCORE SELF-EVALUATION

# WRONG QUESTIONS: ___ / 13 (# TOTAL QUESTIONS) = ___ % YOUR SCORE

## CHAPTER 6 TEST SCORE SELF-EVALUATION

# WRONG QUESTIONS: ___ / 10 (# TOTAL QUESTIONS) = ___ % YOUR SCORE

## CHAPTER 7 TEST SCORE SELF-EVALUATION

# WRONG QUESTIONS: ___ / 16 (# TOTAL QUESTIONS) = ___ % YOUR SCORE

## CHAPTER 8 TEST SCORE SELF-EVALUATION

# WRONG QUESTIONS: ___ / 8 (# TOTAL QUESTIONS) = ___ % YOUR SCORE

## CHAPTER 9 TEST SCORE SELF-EVALUATION

# WRONG QUESTIONS: ___ / 12 (# TOTAL QUESTIONS) = ___ % YOUR SCORE

## CHAPTER 10 TEST SCORE SELF-EVALUATION

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## CHAPTER 11 TEST SCORE SELF-EVALUATION

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## CHAPTER 12 TEST SCORE SELF-EVALUATION

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# ELECTRICITY AND MAGNETISM PRACTICE TEST 1 DIAGNOSTIC

## CHAPTER 6 TEST SCORE SELF-EVALUATION

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# TOTAL QUESTIONS: 1

= ____ % YOUR SCORE

## CHAPTER 14 TEST SCORE SELF-EVALUATION

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## CHAPTER 12 TEST SCORE SELF-EVALUATION

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## CHAPTER 15 TEST SCORE SELF-EVALUATION

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## CHAPTER 13 TEST SCORE SELF-EVALUATION

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## CHAPTER 16 TEST SCORE SELF-EVALUATION

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