Practice Test 1

AP® Physics 2 Exam

SECTION I: Multiple-Choice Questions

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

At a Glance

Total Time
90 minutes
Number of Questions
50
Percent of Total Grade
50%
Writing Instrument
Pen required

Instructions

Section I of this examination contains 50 multiple-choice questions. Fill in only the ovals for numbers 1 through 50 on your answer sheet.

CALCULATORS MAY BE USED IN BOTH SECTIONS OF THE EXAMINATION.

Indicate all of your answers to the multiple-choice questions on the answer sheet. No credit will be given for anything written in this exam booklet, but you may use the booklet for notes or scratch work. After you have decided which of the suggested answers is best, completely fill in the corresponding oval on the answer sheet. Give only one answer to each question. If you change an answer, be sure that the previous mark is erased completely. Here is a sample question and answer.

Sample Question	Sample Answer
Chicago is a (A) state (B) city (C) country (D) continent	Ⓐ ● Ⓒ Ⓓ

Use your time effectively, working as quickly as you can without losing accuracy. Do not spend too much time on any one question. Go on to other questions and come back to the ones you have not answered if you have time. It is not expected that everyone will know the answers to all the multiple-choice questions.

About Guessing

Many candidates wonder whether or not to guess the answers to questions about which they are not certain. Multiple choice scores are based on the number of questions answered correctly. Points are not deducted for incorrect answers, and no points are awarded for unanswered questions. Because points are not deducted for incorrect answers, you are encouraged to answer all multiple-choice questions. On any questions you do not know the answer to, you should eliminate as many choices as you can, and then select the best answer among the remaining choices.

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ADVANCED PLACEMENT PHYSICS 2 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, $1 \text{ eV} = 1.60 \times 10^{-19}$ 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, $N_0 = 6.02 \times 10^{23}$ mol^{-1}	Universal gravitational constant, $G = 6.67 \times 10^{-11}\ \text{m}^3/\text{kg}\cdot\text{s}^2$
Universal gas constant, $R = 8.31$ J/(mol•K)	Acceleration due to gravity at Earth's surface, $g = 9.8\ \text{m/s}^2$
Boltzmann's constant, $k_B = 1.38 \times 10^{-23}$ J/K	

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

PREFIXES

Factor	Prefix	Symbol
10^{12}	tera	T
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

VALUES OF TRIGONOMETRIC FUNCTIONS FOR COMMON ANGLES

θ	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	$4/3$	$\sqrt{3}$	∞

The following conventions are used in this exam.

I. The frame of reference of any problem is assumed to be inertial unless otherwise stated.
II. In all situations, positive work is defined as work done on a system.
III. The direction of current is conventional current: the direction in which positive charge would drift.
IV. Assume all batteries and meters are ideal unless otherwise stated.
V. Assume edge effects for the electric field of a parallel plate capacitor unless otherwise stated.
VI. For any isolated electrically charged object, the electric potential is defined as zero at infinite distance from the charged object.

ADVANCED PLACEMENT PHYSICS 2 EQUATIONS

MECHANICS

$$v_x = v_{x0} + a_x t$$

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

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

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

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

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

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

$$\Delta \vec{p} = \vec{F}\,\Delta t$$

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

$$\Delta E = W = F_{\parallel} d = F d \cos\theta$$

$$P = \frac{\Delta E}{\Delta t}$$

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

$$\omega = \omega_0 + \alpha t$$

$$x = A\cos(\omega t) = A\cos(2\pi f t)$$

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

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

$$\tau = r_{\perp} F = r F \sin\theta$$

$$L = I\omega$$

$$\Delta L = \tau\,\Delta t$$

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

$$|\vec{F}_s| = k|\vec{x}|$$

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

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

$$\Delta U_g = m g \Delta y$$

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

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

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

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

$$\vec{g} = \frac{\vec{F}_g}{m}$$

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

ELECTRICITY AND MAGNETISM

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

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

$$|\vec{E}| = \frac{1}{4\pi\varepsilon_0}\frac{|q|}{r^2}$$

$$\Delta U_E = q\Delta V$$

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$

$$|\vec{E}| = \left|\frac{\Delta V}{\Delta r}\right|$$

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

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

$$E = \frac{Q}{\varepsilon_0 A}$$

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

$$I = \frac{\Delta Q}{\Delta t}$$

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

$$P = I\,\Delta V$$

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

$$R_s = \sum_i R_i$$

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

$$C_p = \sum_i C_i$$

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

$$B = \frac{\mu_0}{2\pi}\frac{I}{r}$$

- A = area
- B = magnetic field
- C = capacitance
- d = distance
- E = electric field
- $\mathcal{E}$ = emf
- F = force
- I = current
- ℓ = length
- P = power
- Q = charge
- q = point charge
- R = resistance
- r = separation
- t = time
- U = potential (stored) energy
- V = electric potential
- v = speed
- κ = dielectric constant
- ρ = resistivity
- θ = angle
- Φ = flux

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

$$|\vec{F}_M| = |q\vec{v}||\sin\theta||\vec{B}|$$

$$\vec{F}_M = I\vec{\ell} \times \vec{B}$$

$$|\vec{F}_M| = |I\vec{\ell}||\sin\theta||\vec{B}|$$

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

$$\Phi_B = |\vec{B}|\cos\theta|\vec{A}|$$

$$\mathcal{E} = -\frac{\Delta\Phi_B}{\Delta t}$$

$$\mathcal{E} = B\ell v$$

ADVANCED PLACEMENT PHYSICS 2 EQUATIONS

FLUID MECHANICS AND THERMAL PHYSICS

$\rho = \frac{m}{V}$

$P = \frac{F}{A}$

$P = P_0 + \rho g h$

$F_b = \rho V g$

$A_1 v_1 = A_2 v_2$

$P_1 + \rho g y_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g y_2 + \frac{1}{2}\rho v_2^2$

$\frac{Q}{\Delta t} = \frac{kA\,\Delta T}{L}$

$PV = nRT = Nk_B T$

$K = \frac{3}{2}k_B T$

$W = -P\Delta V$

$\Delta U = Q + W$

A = area
F = force
h = depth
k = thermal conductivity
K = kinetic energy
L = thickness
m = mass
n = number of moles
N = number of molecules
P = pressure
Q = energy transferred to a system by heating
T = temperature
t = time
U = internal energy
V = volume
v = speed
W = work done on a system
y = height
ρ = density

MODERN PHYSICS

$E = hf$

$K_{\max} = hf - \phi$

$\lambda = \frac{h}{p}$

$E = mc^2$

E = energy
f = frequency
K = kinetic energy
m = mass
p = momentum
λ = wavelength
ϕ = work function

WAVES AND OPTICS

$\lambda = \frac{v}{f}$

$n = \frac{c}{v}$

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$\frac{1}{s_i} + \frac{1}{s_o} = \frac{1}{f}$

$|M| = \left|\frac{h_i}{h_o}\right| = \left|\frac{s_i}{s_o}\right|$

$\Delta L = m\lambda$

$d\sin\theta = m\lambda$

d = separation
f = frequency or focal length
h = height
L = distance
M = magnification
m = an integer
n = index of refraction
s = distance
v = speed
λ = wavelength
θ = angle

GEOMETRY AND TRIGONOMETRY

Rectangle
$A = bh$

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

Circle
$A = \pi r^2$
$C = 2\pi r$

Rectangular solid
$V = \ell wh$

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

Sphere
$V = \frac{4}{3}\pi r^3$
$S = 4\pi r^2$

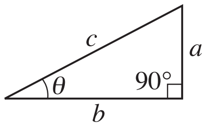
A = area
C = circumference
V = volume
S = surface area
b = base
h = height
ℓ = length
w = width
r = radius

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

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

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

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



AP **PHYSICS 2**

SECTION I

Time—90 minutes

50 Questions

Note: To simplify calculations, you may use $g = 10\ \text{m/s}^2$ in all problems.

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

Questions 1 and 2 refer to the following situation.

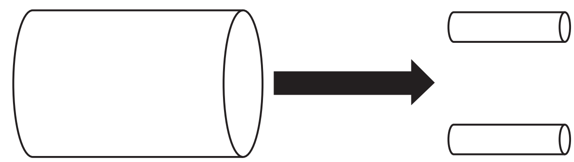
A proton is travelling along a straight line at a constant speed through a uniform electric field near the surface of the Earth.

1. Which of the following choices correctly describes the direction of the electric field and the relative magnitudes of the electric and gravitational fields?

	Electric Field Direction	Field Strength
(A)	Down	$E_g = E_{el}$
(B)	Down	$E_g > E_{el}$
(C)	Up	$E_g = E_{el}$
(D)	Up	$E_g > E_{el}$

2. Which of the following describes the equipotential lines for the electric and gravitational fields that the proton experiences?

(A) Equipotential lines are straight, horizontal lines for both fields.
(B) Equipotential lines are straight, vertical lines for both fields.
(C) Equipotential lines are straight, horizontal lines for the electric field and curve upwards for the gravitational field.
(D) Equipotential lines are straight, horizontal lines for the gravitational field and curve upwards for the electric field.



3. A pipe with a diameter of D splits into two smaller, identical pipes with diameter d. If the speed of the water in the small pipes is v, what is the speed of the water in the large pipe?

(A) dv/D
(B) $2dv/D$
(C) d^2v/D^2
(D) $2d^2v/D^2$

4. A fluid container is shaped as a rectangular prism. The areas of the three faces of the prism are different. Which face of the container should be placed on a horizontal table so that the fluid pressure against the face touching the table is at the the lowest value?

(A) The face with the smallest area
(B) The face with the median area
(C) The face with the largest area
(D) All three orientations will result in the same fluid pressure.

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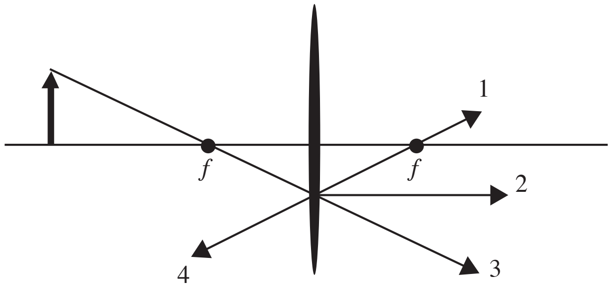
5. An ohmmeter is used to measure resistance. Measurements are made of the cross-sectional area, A, and length, L, of each resistor. What should be plotted so that the slope of the plot will yield the resistivity, ρ, of the resistors?

(A) Resistance on the y-axis versus ratio of L to A on the x-axis
(B) Resistance on the y-axis versus ratio of A to L on the x-axis
(C) Ratio of L to A on the y-axis versus resistance on the x-axis
(D) Ratio of A to L on the y-axis versus resistance on the x-axis

6. An ideal gas is taken from an initial set of conditions with pressure P_i and volume V_i, to a final set of conditions, with pressure P_f and volume V_f, through several different processes. At the end of the process, the gas is at both a higher pressure and a larger volume than when it started. Which process requires the least amount of work on the system?

(A) First, expansion at constant pressure P_i from V_i to V_f followed by increasing pressure from P_i to P_f at constant volume V_f.
(B) First, increasing pressure from P_i to P_f at constant V_i volume followed by expansion at constant pressure P_f from V_i to V_f
(C) A series of small increases in volume alternating with small increases in pressure, resulting in a nearly straight line on a PV graph from the beginning to the end of the process.
(D) Any set of steps will require the same amount of work because all gases have the same change in pressure and volume.

Questions 7 and 8 refer to the following diagram.



7. The image above shows a converging lens and an object represented as a bold vertical arrow. Which line correctly depicts the output path of the ray for the ray that is incident on the lens coming in through the focus?

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

8. The converging lens above has a focal length of 25 cm. The object is located at a distance of 65 cm from the lens. Where should a screen be placed so that the observer will see a focused image on the screen?

(A) 65 cm to the right side of the lens
(B) 40.6 cm to the right side of the lens
(C) At the focus of the lens
(D) The image in such an arrangement will be virtual and cannot be seen on a screen.

9. You are tasked with creating a real image using a concave mirror as your imaging system. Which of the following criteria is true about both the image and the object?

(A) A real image can be created only if the object is farther away from the lens than the radius of curvature of the lens.
(B) A real image can be created only with the object located between the center of the lens and the focal length of the lens.
(C) A real image can be created with the object located anywhere farther from the lens than the focal point.
(D) A real image cannot be created using only a concave lens.

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10. An atom has its lowest four energy levels at –10 eV, –5 eV, –3.5 eV, –2 eV. Which of the following photons could not be absorbed by the atom?

(A) A 10 eV photon
(B) A 5 eV photon
(C) A 2.5 eV photon
(D) A 1.5 eV photon

11. A radioactive particle undergoes beta decay, emitting an electron from its nucleus. Which of the following explanations correctly explains why this process must also involve a neutron turning into a proton within the nucleus?

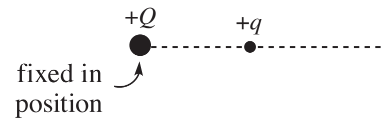
(A) The total charge of the system before and after is not the same if the proton is not created.
(B) The mass energy of the system is not conserved if the proton is not created.
(C) The momentum of the system could not be conserved without the generation of a proton.
(D) All nuclear decay processes involve the generation of two particles.

12. A thermodynamic process is conducted wherein an ideal gas is taken from state A to B to C to D to A. State A is at a pressure P and a volume 5V. State B is at pressure 4P and volume V. State C is at pressure 4P and volume 4V. state D is at pressure 2P and volume 10V. Which step in the process requires the largest change in internal energy of the system?

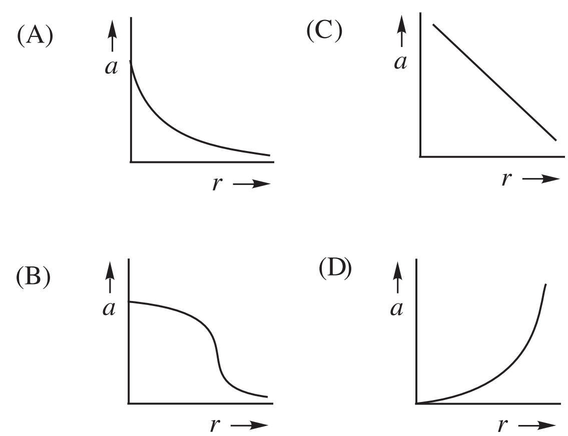
(A) State A to State B
(B) State B to State C
(C) State C to State D
(D) State D to State A

13. A circuit consists of a 50 V battery, a 100 Ω resistor and a 25 μF capacitor. Once the capacitor has become fully charged, how much energy is stored in the capacitor?

(A) 0.0013 J
(B) 0.031 J
(C) 0.062 J
(D) 0.125 J



14. As shown above, the $+Q$ charge is fixed in position, and the $+q$ charge is brought close to $+Q$ and then released from rest. Which graph best shows the acceleration of the $+q$ charge as a function of its distance r from $+Q$?



15. A charged particle with mass m is moving at a speed v at one particular instant in time. The particle is later found at a position with an electrical potential of ΔV higher than its initial position, and a gravitational potential equal to its original position. Which mathematical routine could be used to determine its speed in the final position?

(A) Calculate the work from the electrical potential and use conservation of energy to find the final speed.
(B) Calculate the work from the gravitational potential and use conservation of energy to find the final speed.
(C) Calculate the impulse from the electric potential and use conservation of momentum to find the final speed.
(D) Calculate the impulse from the gravitational potential and use conservation of momentum to find the final speed.

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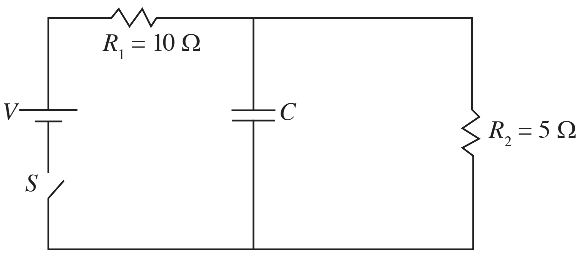
Questions 16-18 refer to the following diagram.



16. Voltmeters are placed across the Resistor R_1, the capacitor C, and the resistor R_2. The switch S has been closed a long time. What is the rank of the value readings on the voltmeters?

(A) $V_{R_1} > (V_C = V_{R_2})$
(B) $(V_{R_1} = V_C = V_{R_2})$
(C) $(V_C = V_{R_2}) > V_{R_1}$
(D) $V_{R_1} > V_C > V_{R_2}$

17. The circuit is reset and the capacitor is discharged. Then, the switch is closed again. At what time will the current through the resistor R_2 be greatest?

(A) The current through the resistor will be constant.
(B) The current through the resistor will be greatest before closing the switch.
(C) The current through the resistor will be greatest immediate after closing the switch.
(D) The current through the resistor will be greatest a long time after closing the switch.

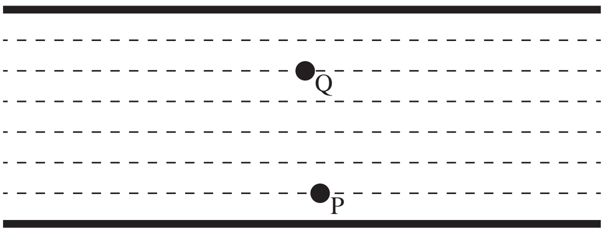
18. The capacitance of the capacitor is known initially. The capacitor is now altered to have a larger capacitance. Which of the following observations will occur with the new capacitor in the circuit a long time after the switch is closed as compared to what was observed a long time after the switch was closed with the original capacitor?

(A) The current flowing in R_1 will be greater.
(B) The current flowing in R_2 will be greater.
(C) The current flowing into the capacitor will be greater.
(D) There will be no observed change in the circuit.

19. An ideal gas is confined within a cube shaped container. In addition to the length of the side of the container, which of the following sets of measurements will allow a student to determine the pressure of the gas in the container?

I. The mass of gas in the container and the average speed of a gas molecule.
II. The impulse delivered to the gas by a wall in a measured time period.
III. The force of the gas against one of the walls.

(A) I only
(B) III only
(C) II or III
(D) I or II or III



20. Points P and Q lie between the plates of a fully charged parallel plate capacitor as shown above. The lower plate is negatively charged and the upper plate is positively charged. How do the magnitudes of the electric fields at points P and Q compare?

(A) The field is 0 N/C at both points.
(B) The field is the same at both points, but not 0 N/C.
(C) $E_P > E_Q$
(D) $E_Q > E_P$

21. A wire carries a constant current to the right. A positively charged particle is a distance d above the wire, and it is moving in the same direction as the current. The particle will experience a magnetic force in which direction?

(A) To the right
(B) To the top of the page
(C) To the left
(D) To the bottom of the page

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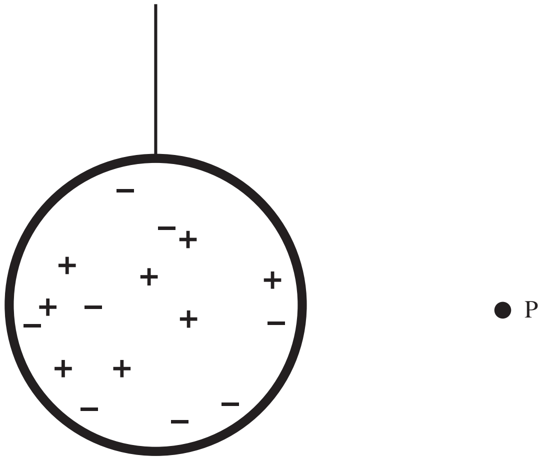


22. A neutral conducting sphere is hung from a thin insulating string. A positively charged object is brought to point P. The two objects are not allowed to touch. What is true about the string when the positively charged object is present at point P?

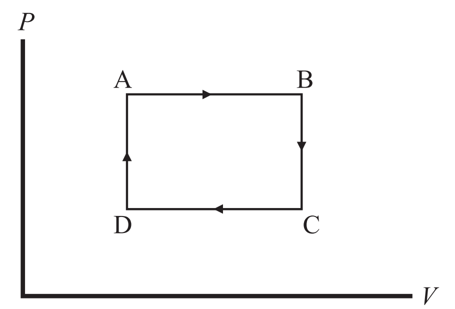
(A) The tension is the same as before the object was present at point P.
(B) The tension is greater than when the object was not at point P and the string stretches to the left of its original orientation.
(C) The tension is greater than when the object was not at point P and the string stretches to the right of its original orientation.
(D) The tension is less than when the object was not at point P and the string stretches to the left of its original orientation.

23. An experiment is performed on a fixed volume of an ideal gas. The pressure, in pascals, of the gas is plotted on the vertical axis and the temperature of the gas, in degrees Kelvin, is plotted on the horizontal axis. During a second performance of the experiment at a greater volume, the pressure-temperature gas is expected to

(A) have a greater slope and the same intercept
(B) have a smaller slope and the same intercept
(C) have a greater slope and a greater intercept
(D) have a smaller slope and a greater intercept

24. Two gas samples contain different gases. The first gas sample contains more massive molecules than the second. The molecules in both gas samples have the same average speed. When the samples are brought into contact, what is the flow of energy?

(A) No energy will flow because the average speed of the particles in each gas is the same.
(B) No energy will flow because the gases are made up of different molecules.
(C) Energy will flow away from the first sample because its molecules are more massive.
(D) Energy will flow away from the first sample because its molecules have more kinetic energy.



25. Which statement correctly characterizes the work done by the gas during the ABCA cycle shown in the above *P*-*V* diagram?

(A) There is no work done by the gas because the system both starts and concludes in state A.
(B) There is no work done because the work done during the transition from A→B cancels out the work done in transition from C→D.
(C) The work done by the gas is positive because the work done during the transition from A→B is greater than the work done in transition from C→D.
(D) The work done by the gas is positive because the work done during the transition from B→C is greater than the work done in transition from D→A.

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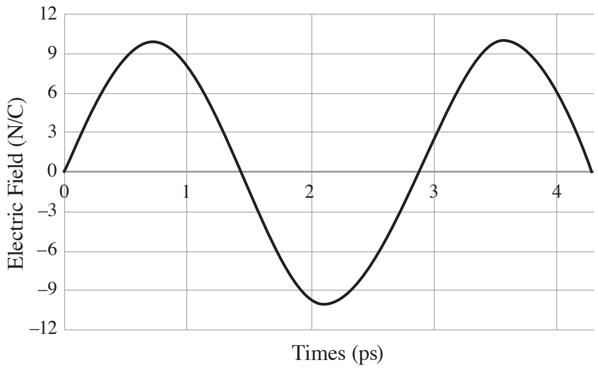

26. What is the equation for the electric field given by the above plot? The electric field crosses the axis at times 0 ps, 1.43 ps, 2.85 ps, and 4.28 ps.

(A) $E = \left(\frac{0\text{ N}}{\text{C}}\right)\sin((2.85\text{ THz})t)$

(B) $E = \left(\frac{10\text{ N}}{\text{C}}\right)\sin((2.85\text{ THz})t)$

(C) $E = \left(\frac{10\text{ N}}{\text{C}}\right)\sin((2.20\text{ THz})t)$

(D) $E = \left(\frac{10\text{ N}}{\text{C}}\right)\cos((0.45\text{ THz})t)$

27. A spherical balloon filled with helium is floating in air. If the balloon is inflated until its radius is doubled, how will the buoyant force on the balloon be affected?

(A) It will decrease by a factor of 4.
(B) It will increase by a factor of 4.
(C) It will increase by a factor of 8.
(D) It will not be affected.

28. Data is collected in an experiment preformed on an ideal gas. In the experiment, temperature (in K) is the independent variable and volume (in m^3) is the dependent variable. If the data is graphed, which of the following is true about the slope and *y*-intercept of the graph?

(A) The slope will be directly proportional to the pressure of the gas and the intercept will be 0 m^3.
(B) The slope will be inversely proportional to the pressure of the gas and the intercept will be 0 m^3.
(C) The slope will be directly proportional to the pressure of the gas and the intercept will not be 0 m^3.
(D) The slope will be inversely proportional to the pressure of the gas and the intercept will not be 0 m^3.

29. Which of the following relationships, when plotted, will yield a curve which is inverse to the first power?

I. The electric potential versus distance from a positive point particle.
II. The volume versus pressure for an ideal gas.
III. The magnetic field from a current carrying wire versus distance from the wire.

(A) I only
(B) I and III
(C) II only
(D) I and II and III

30. A massive charged object is fixed in space with a separation of *d* meters. A quantity *R* is defined as the ratio of the gravitational potential energy to the electric potential energy. The separation is then increased slowly. What happens to *R*?

(A) *R* is constant for all separations.
(B) *R* increases as the separation increases.
(C) *R* decreases as the separation increases.
(D) *R* increases up to a distance *D*, then R decreases back to its original value.

31. An ideal gas is at a pressure *P* and a volume *V*. The gas is in a fixed volume, but is heated until the pressure doubles. What happens to the average speed of the molecules in the gas?

(A) The speed of the molecules on average remain unchanged.
(B) The speed of the molecules on average increases by a factor of $\sqrt{2}$.
(C) The speed of the molecules on average increases by a factor of 2.
(D) The speed of the molecules on average increases by a factor of 4.

32. Which of the following changes to a double-slit interference experiment would increase the widths of the fringes in the interference pattern that appears on the screen?

(A) Use light of a shorter wavelength.
(B) Move the screen closer to the slits.
(C) Move the slits closer together.
(D) Use light with a lower wave speed.

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33. Tritium is an isotope of hydrogen consisting of one proton and two neutrons. The isotope has a mass of 5.008×10^{-27} kg. The mass of a proton is 1.673×10^{-27} kg and a neutron has a mass of 1.675×10^{-27} kg. What is the binding energy of tritium?

(A) 1.500×10^{-29} J
(B) 1.350×10^{-12} J
(C) 4.507×10^{-10} J
(D) 4.521×10^{-10} J

34. In an experiment designed to study the photoelectric effect, it is observed that low-intensity visible light of wavelength 550 nm produced no photoelectrons. Which of the following best describes what would occur if the intensity of this light were increased dramatically?

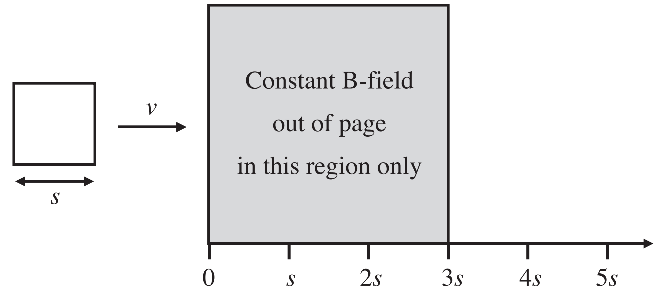
(A) Almost immediately, photoelectrons would be produced with a kinetic energy equal to the energy of the incident photons.
(B) Almost immediately, photoelectrons would be produced with a kinetic energy equal to the energy of the incident photons minus the work function of the metal.
(C) After several seconds, the electrons absorb sufficient energy from the incident light, photoelectrons would be produced with a kinetic energy equal to the energy of the incident photons minus the work function of the metal.
(D) Nothing would happen.

35. Radioactive carbon-14 undergoes beta-minus decay. The atomic number of carbon is 6. The number of nucleons in the products after the beta decay is

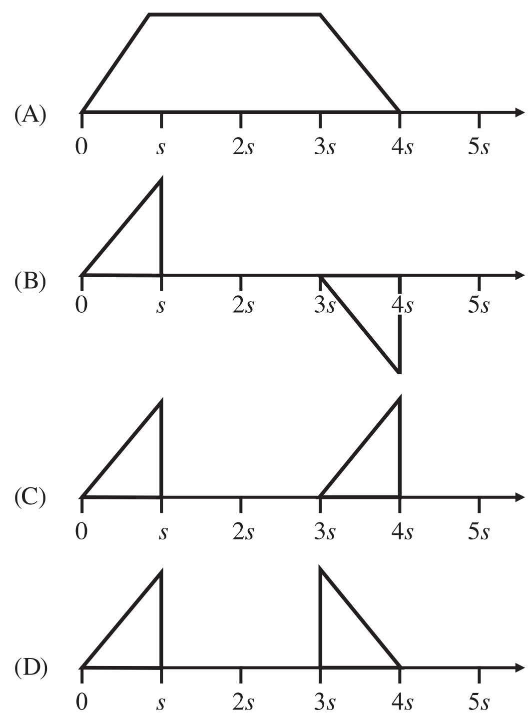
(A) 6
(B) 7
(C) 13
(D) 14

36. A pipe carries water with a density of $\rho = 1000$ kg/m^3. One end of the pipe has a diameter of 0.02 m. At that location, a pressure gauge says the pressure is $P = 1.25 \times 10^5$ Pa and the water is moving at a speed of 2.0 m/s. The other end of the pipe is 1.2 m higher than the end with the pressure gauge and a diameter of 0.01 m. What will a pressure gauge installed in the upper end of the pipe read?

(A) 7.90×10^4 Pa
(B) 8.30×10^4 Pa
(C) 1.07×10^5 Pa
(D) 1.43×10^5 Pa



37. A square loop of conducting wire with side s is moved at a constant rate v to the right into a region where there is a constant magnetic field directed out of the page. Which of the following graphs shows the flux through the loop as a function of distance?



38. A hollow conducting sphere is placed around point P so that the center is at P. What happens to the electric field strength at point P?

(A) It doubles.
(B) It halves.
(C) It remains unchanged.
(D) It becomes zero.

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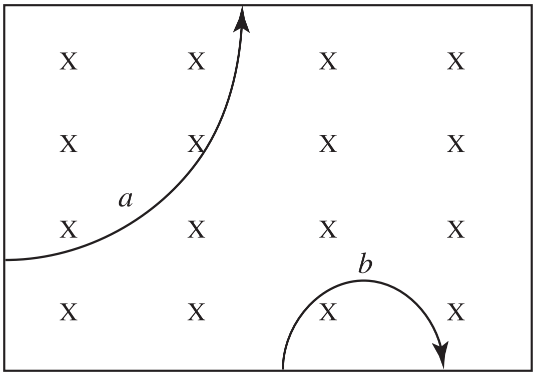
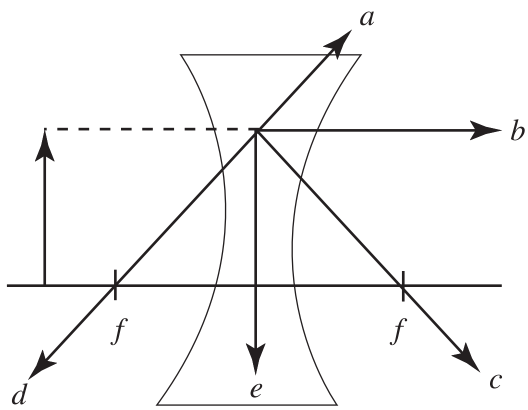


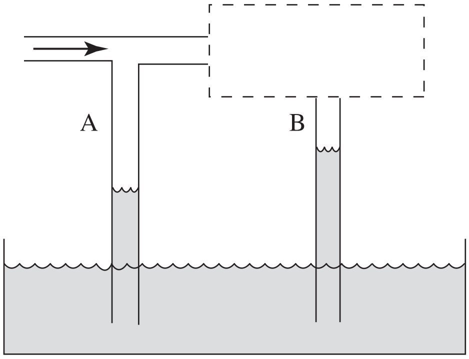
39. A machine shoots a proton, a neutron, or an electron into a magnetic field at various locations. The paths of two particles are shown above. Assume they are far enough apart so that they do not intersect and the magnetic field is going out of the page. What can you say about the paths that represent each particle?

(A) *a* is the proton and *b* is the electron.
(B) *b* is the proton and *a* is the electron.
(C) Either may be a neutron.
(D) You cannot make any conclusions without knowing the velocities.



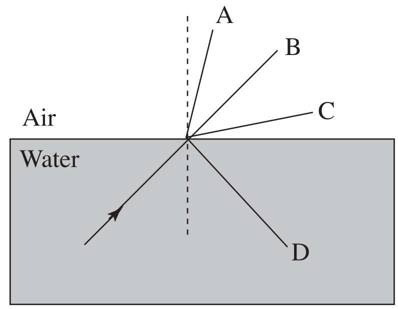
40. In the figure above, a ray of light hits an object and travels parallel to the principal axis as shown by the dotted line. Which line shows the correct continuation of the ray after it hits the concave lens?

(A) *a*
(B) *b*
(C) *c*
(D) *d*



41. A tube with two T branches that has an open end is inserted in a liquid. However, the section of the tube above part B is hidden from view. The hidden section may be wider or narrower. Air is blown through the tube and the water levels rise as shown. You can conclude which of the following?

(A) The picture as drawn is impossible—A and B must be at equal heights.
(B) The tube is narrower and the air speed is greater above section B.
(C) The tube is narrower and the air speed is less above section B.
(D) The tube is wider and the air speed is greater above section B.



42. A beam of light goes from water to air. Depending on the actual angle that the light strikes the surface, which of the following rays are possible outcomes?

(A) A only
(B) B only
(C) A or D
(D) C or D

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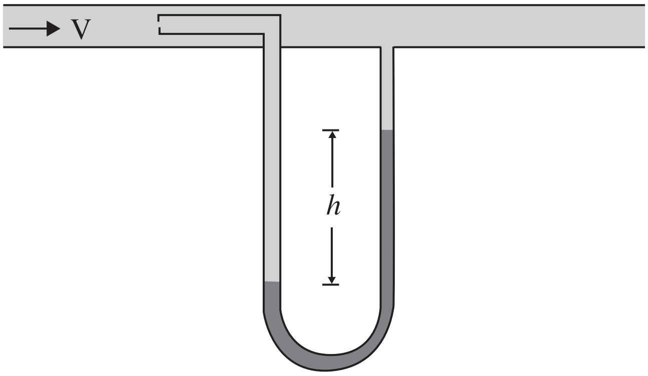

43. The instrument in an aircraft to measure airspeed is known as the pitot tube, shown in the figure above. The opening facing the incoming air (with the small aperture) is the part meant to capture the air at rest. The opening perpendicular to the flow of air (with the large aperture) is meant to capture air at speed. If h = 1 m and the fluid within the manometer is water, what is the airspeed? Take the density of air to be ρ_{air} = 1.2 kg/m^3.

(A) 27 m/s
(B) 68 m/s
(C) 95 m/s
(D) 128 m/s

44. Two charged, massive particles are isolated from all influence except those between the particles. They have charge and mass such that the net force between them is 0 N. Which of the following is NOT true?

(A) The particles must have the same sign of charge.
(B) If the distance between the particles changes, the force will no longer be 0 N.
(C) The particles must have the same mass.
(D) The particle cannot have the same magnitude of charge.

45. The following three step process refers to a simple RC circuit with a battery and an initially open switch.

Step 1: The switch is closed, allowing the capacitor to charge.

Step 2: After the capacitor has charged, a slab of dielectric material is inserted between the plates of the capacitor and time passes.

Step 3: The switch is opened, and the dielectric is removed.

Which of the following describes the change in potential energy stored in the capacitor during each step?

(A) $\Delta U_1 < 0; \Delta U_2 > 0; \Delta U_3 > 0$
(B) $\Delta U_1 > 0; \Delta U_2 > 0; \Delta U_3 > 0$
(C) $\Delta U_1 < 0; \Delta U_2 > 0; \Delta U_3 < 0$
(D) $\Delta U_1 > 0; \Delta U_2 < 0; \Delta U_3 < 0$

Directions: For questions 46-50 below, two of the suggest answers will be correct. Select the two answers that are best in each case, and then fill in both of the corresponding circles on the answer sheet.

46. N resistors (N > 2) are connected in parallel with a battery of voltage V_0. If one of the resistors is removed from the circuit, which of the following quantities will decrease? Select two answers.

(A) The voltage across any of the remaining resistors
(B) The current output by the battery
(C) The total power dissipated in the circuit
(D) The total resistance in the circuit

47. A metal conducting sphere of radius r in electrostatic equilibrium has a positive net charge of +5e. Which of the following is true? Select two answers.

(A) All of the charge will be located on the outside of the sphere.
(B) There will be a constant, non-zero electric field within the sphere.
(C) There will be a constant, non-zero electric potential within the sphere.
(D) When the sphere is connected to a ground, the +5e of charge on the sphere will flow into the ground to neutralize the sphere.

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48. A circuit is created with a battery of negligible internal resistance and three identical resistors with resistance of 10 Ω. The resistors are originally arranged so that one is in series with the battery, and the other two are in parallel with one another. Which of the following changes to the circuit will result in an increase in the amount of current drawn from the battery? Select two answers.

(A) Rearranging the resistors so that all three are in parallel
(B) Replacing every resistor with a resistor of half the resistance
(C) Removing one of the two parallel branches entirely from the circuit
(D) Replacing the battery with a battery with half the voltage

49. An ideal gas is in state 1, with P_1, V_1, and T_1. The final volume will be the same as V_1 for which of the following processes? Select two answers.

(A) Triple P_1 and decrease T_1 by $\frac{1}{3}$
(B) Triple T_1 and decrease P_1 by $\frac{1}{3}$
(C) Quadruple P_1 and T_1
(D) Decrease P_1 by $\frac{1}{3}$ and decrease T_1 by $\frac{1}{3}$

50. In a double slit experiment, students are attempting to increase the spacing of the fringes observed on the screen. Which modifications to the set up will result in increased fringe separation? Select two answers.

(A) Doubling the wavelength only
(B) Doubling the wavelength and doubling the slit separation
(C) Doubling the distance to the screen only
(D) Doubling the distance to the screen and doubling the slit separation

END OF SECTION I

AP PHYSICS 2

SECTION II

Time—90 minutes

4 Questions

Directions: Questions 1 and 2 are long free-response questions that require about 30 minutes to answer. Questions 3 and 4 are short answer questions that require about 15 minutes to answer. Show your work for each part in the space provided after that part.

1. An unplugged freezer is at room temperature. The door is closed and the freezer is plugged in.

(a) Your friend observes, "When you open the freezer, the cold air comes out of the freezer. That didn't happen before the freezer was cooled down. It must therefore be the case that cold air is less dense than warm air, since the low density gas will expand more easily."

(i) Is there any part of your friend's statement you agree with? Why?

(ii) Is there any part of your friend's statement you disagree with? Why?

(b) You set out to perform an experimental investigation of the relationship between gas density and temperature. The following equipment is available. Place an X beside each item you will need to use:

	Chamber with sliding piston lid with a known area		Chamber with fixed lid with a known area
	Pressure monitor		Thermometer
	Meter stick		Stopwatch
	Large tub of boiling water		Large tub of ice water

(c) Write out a numbered procedure you will use to gather necessary data. Your description should be detailed enough that another student could reproduce your experiment.

(d) Your data analysis must include a graph. Explain what you would graph on the x-axis and the y-axis. Justify your decision and explain how your graph will help you understand the relationship between density of a gas and its temperature.

(e) What shape graph do you expect to see?

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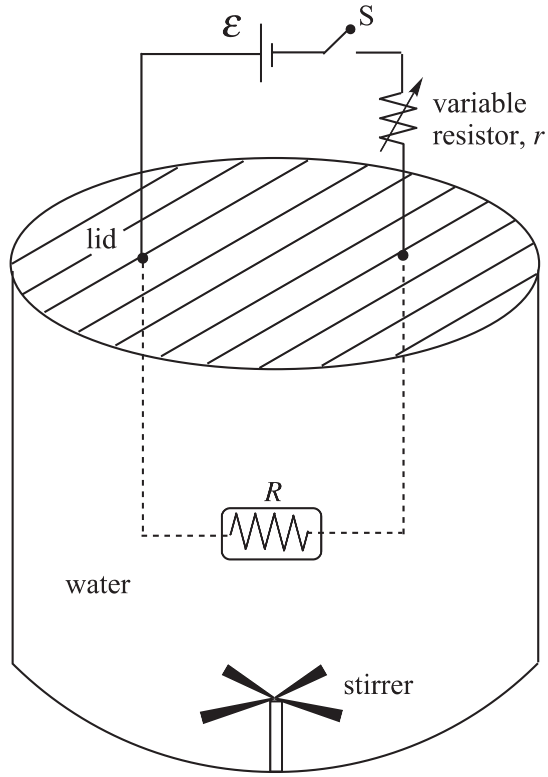
2. The figure below shows an electric circuit containing a source of emf, ε, a variable resistor (r) and a resistor of fixed resistance R. The resistor R is immersed in a sealed beaker containing a mass m of water, currently at temperature T_i. When the switch S is closed, current through the circuit causes the resistor in the water to dissipate heat, which is absorbed by the water. A stirrer at the bottom of the beaker simply ensures that the temperature is uniform throughout the water at any given moment. The apparatus is well-insulated (insulation not shown), and it may be assumed that no heat is lost to the walls or lid of the beaker or to the stirrer.



(a) Determine the current in the circuit once S is closed. Write your answer in terms of ε, r, and R.

(b) Determine the power dissipated by the resistor R in terms of ε, r, and R.

(c) Explain at the microscopic level why the water heats up when the switch is closed and how the stirrer helps ensure a constant temperature throughout.

(d) Assume the stirrer has a knob, which changes its speed. How can the temperature of the water be increased more rapidly by adjusting the rotation rate of the stirrer?

(e) As the temperature of the water increases, whether from the resistor or from the stirrer rate, explain the microscopic interactions responsible for the changing pressure in the container.

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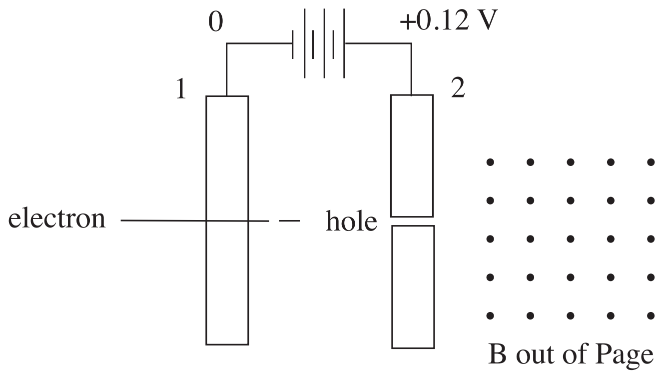
3. In an experiment conducted, two tests are run. In both trials you may ignore the effect of gravity. The following is a diagram of the tests.



Test 1: There are two large parallel plates separated by a distance $d = 0.5$ m with a potential difference of 0.12 V across them. There is a uniform magnetic field **B** pointing perpendicularly out of the paper of strength 0.002 T starting to the right of plate 2. An electron is released from rest at plate 1 as shown above. It passes through a hole in plate 2 and enters the magnetic field and only experiences forces due to the magnetic field.

Test 2: The same set-up is run with the following two exceptions.

1. The battery is switched so that plate 1 becomes positive and plate 2 becomes negative.

2. A proton is used instead of an electron.

(a) As the particles move from plate 1 towards plate 2 in each test, they experience unbalanced forces causing their speed to change. After plate 2, each particle still experiences unbalanced forces, but no longer change speed. Use the concept of work to explain how this occurs.

(b) Find the ratio of the speed of the proton as it emerges from the hole to the speed of the electron as it emerges from the hole.

(c) Make a sketch of each path each particle will follow after emerging from the hold in plate 2.

(d) A third test is conducted similar to test 2, except an alpha particle is used instead of a proton. Explain how the path of the alpha particle after emerging from the hole will differ from the proton path.

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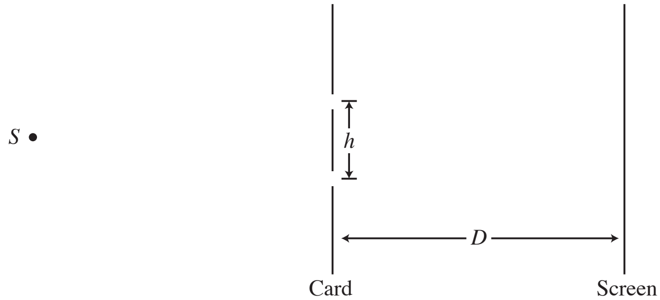

Note: Figure not drawn to scale.

4. In a double-slit interference experiment, a parallel beam of monochromatic light is needed to illuminate two narrow parallel slits of width w that are a distance h apart, where $h >> w$, in an opaque card as shown in the figure above. The interference pattern is formed on a screen a distance D from the slits, where $D >> h$.

(a) Explain why it is important that the distance between S and the card is much greater than the distance h.

(b) Draw the first three wavefronts that emerge from each slit after the card.

(c) In the interference patterns on the screen, the distance from the central bright fringe to the third bright fringe on one side is measured to be y_3. In terms of D, H, y_3 and S, what is the wavelength of the light emitted from the source S?

(d) If the space between the slits and the screen was filled with a material having an index of refraction $n > 1$, would the distance between the bright fringes increase, decrease, or remain the same? Explain your reasoning.

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.: ______________________________ (Print)

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
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4. REGISTRATION NUMBER

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5. YOUR NAME

First 4 letters of last name					FIRST INIT	MID INIT
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6. DATE OF BIRTH

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SEP		7	7	7
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NOV		9	9	9
DEC				

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