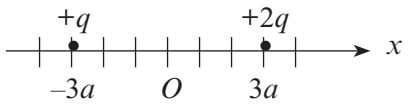
AP Physics C: Electricity and Magnetism Sample Multiple-Choice Questions

Most of the following sample questions have appeared in past exams.

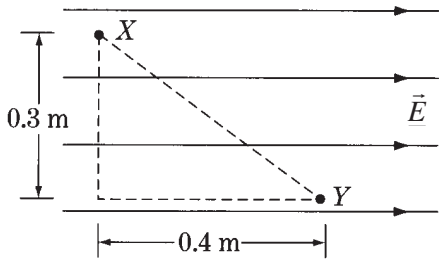
Note: Units associated with numerical quantities are abbreviated, using the abbreviations listed in the table of information included with the exams.

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.



1. Two charges are located on the x-axis of a coordinate system as shown above. The charge $+2q$ is located at $x = +3a$ and the charge $+q$ is located at $x = -3a$. Where on the x-axis should an additional charge $+4q$ be located to produce an electric field equal to zero at the origin O?

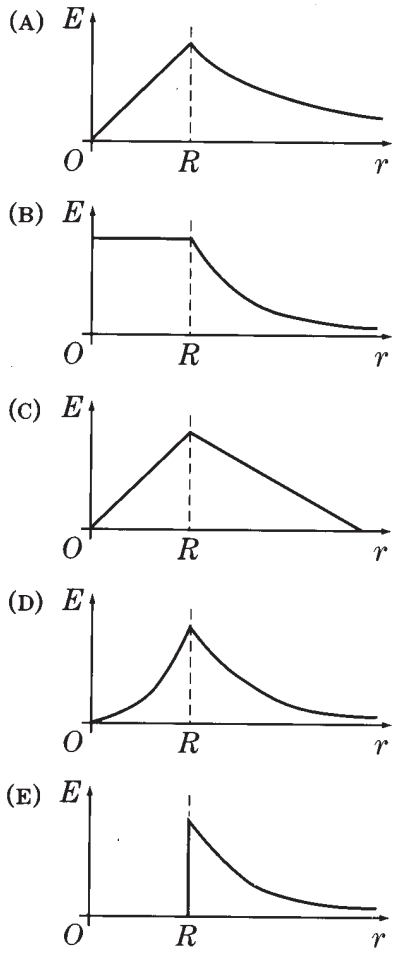
   (A) $x = -6a$
   (B) $x = -2a$
   (C) $x = +a$
   (D) $x = +2a$
   (E) $x = +6a$

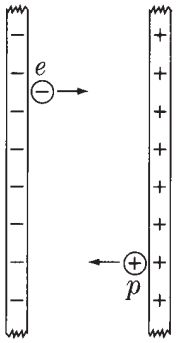


2. A uniform electric field $\vec{E}$ of magnitude 6,000 V/m exists in a region of space as shown above. What is the electric potential difference, $V_X - V_Y$, between points X and Y?

   (A) –12,000 V
   (B) 0 V
   (C) 1,800 V
   (D) 2,400 V
   (E) 3,000 V

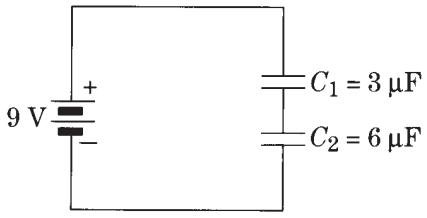
3. Charge is distributed uniformly throughout a long nonconducting cylinder of radius R. Which of the following graphs best represents the magnitude of the resulting electric field E as a function of r, the distance from the axis of the cylinder?





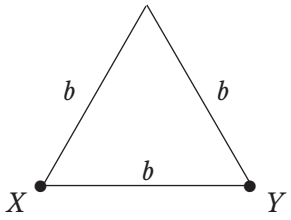
4. A proton *p* and an electron *e* are released simultaneously on opposite sides of an evacuated area between large, charged parallel plates, as shown above. Each particle is accelerated toward the oppositely charged plate. The particles are far enough apart so that they do not affect each other. Which particle has the greater kinetic energy upon reaching the oppositely charged plate?

   (A) The electron
   (B) The proton
   (C) Neither particle; both kinetic energies are the same.
   (D) It cannot be determined without knowing the value of the potential difference between the plates.
   (E) It cannot be determined without knowing the amount of charge on the plates.



5. Two capacitors initially uncharged are connected in series to a battery, as shown above. What is the charge on the top plate of C_1?

   (A) –81 μC
   (B) –18 μC
   (C) 0 μC
   (D) +18 μC
   (E) +81 μC



6. Wire of resistivity ρ and cross-sectional area A is formed into an equilateral triangle of side b, as shown above. The resistance between two vertices of the triangle, X and Y, is

(A) $\frac{3}{2}\frac{A}{\rho b}$

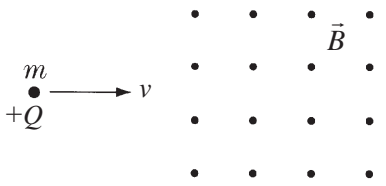
(B) $3\frac{A}{\rho b}$

(C) $\frac{2}{3}\frac{\rho b}{A}$

(D) $\frac{3}{2}\frac{\rho b}{A}$

(E) $3\frac{\rho b}{A}$

Questions 7–8



A particle of electric charge $+Q$ and mass m initially moves along a straight line in the plane of the page with constant speed v, as shown above. The particle enters a uniform magnetic field of magnitude B directed out of the page and moves in a semicircular arc of radius R.

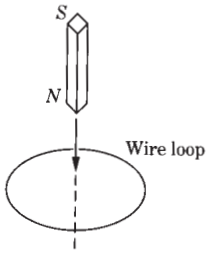
7. Which of the following best indicates the magnitude and the direction of the magnetic force $\vec{F}$ on the charge just after the charge enters the magnetic field?

	Magnitude	Direction
(A)	$\frac{kQ^2}{R^2}$	Toward the top of the page
(B)	$\frac{kQ^2}{R^2}$	Toward the bottom of the page
(C)	QvB	Out of the plane of the page
(D)	QvB	Toward the top of the page
(E)	QvB	Toward the bottom of the page

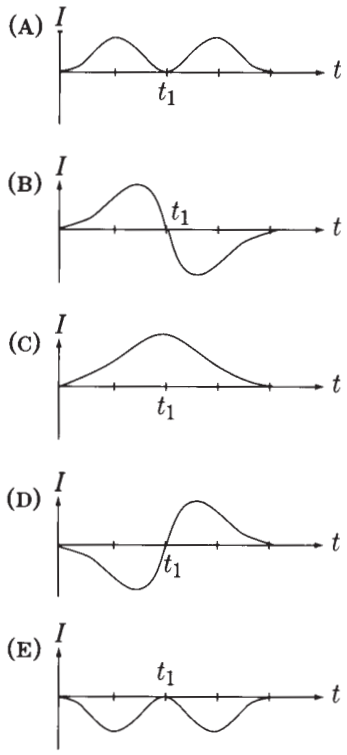
8. If the magnetic field strength is increased, which of the following will be true about the radius R?

I. R increases if the incident speed is held constant.
II. For R to remain constant, the incident speed must be increased.
III. For R to remain constant, the incident speed must be decreased.

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



9. A bar magnet is lowered at constant speed through a loop of wire as shown in the diagram above. The time at which the midpoint of the bar magnet passes through the loop is t_1. Which of the following graphs best represents the time dependence of the induced current in the loop? (A positive current represents a counterclockwise current in the loop as viewed from above.)



10. A loop of wire enclosing an area of 1.5 m^2 is placed perpendicular to a magnetic field. The field is given in teslas as a function of time t in seconds by

$$B(t) = \frac{20t}{3} - 5$$

The induced emf in the loop at $t = 3$ s is most nearly

(A) 0 V
(B) 5 V
(C) 10 V
(D) 15 V
(E) 20 V

Answers to AP Physics C: Electricity and Magnetism Multiple-Choice Questions

1 – A	3 – A	5 – D	7 – E	9 – B
2 – D	4 – C	6 – C	8 – B	10 – C

AP Physics C: Mechanics Sample Multiple-Choice Questions

Most of the following sample questions have appeared in past exams. The answers are on page 44. Additional questions can be found in the 2009 *AP Physics B and Physics C Released Exams* book.

Note: Units associated with numerical quantities are abbreviated, using the abbreviations listed in the table of information included with the exams (see insert in this book). 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 five suggested answers or completions. Select the one that is best in each case.

Questions 1–2

The speed v of an automobile moving on a straight road is given in meters per second as a function of time t in seconds by the following equation:

$$v(t) = 4 + 2t^3$$

1. What is the acceleration of the automobile at $t = 2$ s?

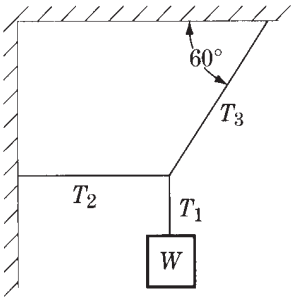
   (A) $12\ \text{m/s}^2$
   (B) $16\ \text{m/s}^2$
   (C) $20\ \text{m/s}^2$
   (D) $24\ \text{m/s}^2$
   (E) $28\ \text{m/s}^2$

2. How far has the automobile traveled in the interval between $t = 0$ and $t = 2$ s?

   (A) 16 m
   (B) 20 m
   (C) 24 m
   (D) 32 m
   (E) 72 m

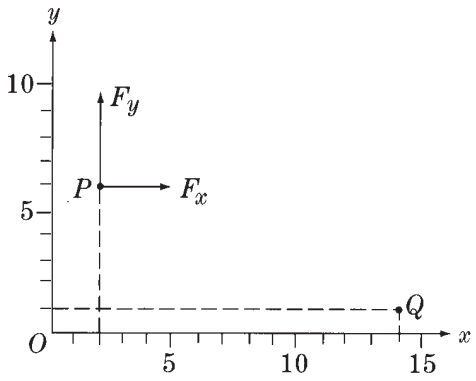
3. If a particle moves in a plane so that its position is described by the functions $x = A \cos \omega t$ and $y = A \sin \omega t$, the particle is

   (A) moving with constant speed along a circle
   (B) moving with varying speed along a circle
   (C) moving with constant acceleration along a straight line
   (D) moving along a parabola
   (E) oscillating back and forth along a straight line



4. A system in equilibrium consists of an object of weight W that hangs from three ropes, as shown above. The tensions in the ropes are T_1, T_2, and T_3. Which of the following are correct values of T_2 and T_3?

	T_2	T_3
(A)	$W \tan 60°$	$\dfrac{W}{\cos 60°}$
(B)	$W \tan 60°$	$\dfrac{W}{\sin 60°}$
(C)	$W \tan 60°$	$W \sin 60°$
(D)	$\dfrac{W}{\tan 60°}$	$\dfrac{W}{\cos 60°}$
(E)	$\dfrac{W}{\tan 60°}$	$\dfrac{W}{\sin 60°}$

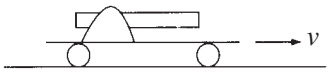


5. The constant force $\vec{F}$ with components $F_x = 3$ N and $F_y = 4$ N, shown above, acts on a body while that body moves from the point P ($x = 2$ m, $y = 6$ m) to the point Q ($x = 14$ m, $y = 1$ m). How much work does the force do on the body during this process?

   (A) 16 J
   (B) 30 J
   (C) 46 J
   (D) 56 J
   (E) 65 J

6. The sum of all the external forces on a system of particles is zero. Which of the following must be true of the system?

   (A) The total mechanical energy is constant.
   (B) The total potential energy is constant.
   (C) The total kinetic energy is constant.
   (D) The total linear momentum is constant.
   (E) It is in static equilibrium.



7. A toy cannon is fixed to a small cart and both move to the right with speed v along a straight track, as shown above. The cannon points in the direction of motion. When the cannon fires a projectile the cart and cannon are brought to rest. If M is the mass of the cart and cannon combined without the projectile, and m is the mass of the projectile, what is the speed of the projectile relative to the ground immediately after it is fired?

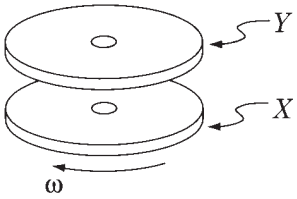
(A) $\frac{Mv}{m}$

(B) $\frac{(M+m)v}{m}$

(C) $\frac{(M-m)v}{m}$

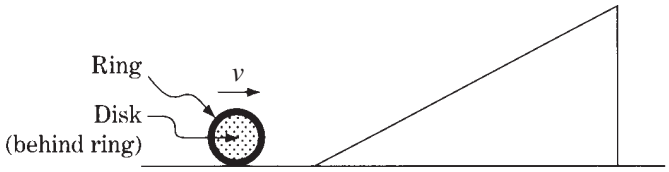
(D) $\frac{mv}{(M)}$

(E) $\frac{mv}{(M-m)}$



8. A disk X rotates freely with angular velocity ω on frictionless bearings, as shown above. A second identical disk Y, initially not rotating, is placed on X so that both disks rotate together without slipping. When the disks are rotating together, which of the following is half what it was before?

(A) Moment of inertia of X
(B) Moment of inertia of Y
(C) Angular velocity of X
(D) Angular velocity of Y
(E) Angular momentum of both disks



9. The ring and the disk shown above have identical masses, radii, and velocities, and are not attached to each other. If the ring and the disk each roll without slipping up an inclined plane, how will the distances that they move up the plane before coming to rest compare?

   (A) The ring will move farther than will the disk.
   (B) The disk will move farther than will the ring.
   (C) The ring and the disk will move equal distances.
   (D) The relative distances depend on the angle of elevation of the plane.
   (E) The relative distances depend on the length of the plane.

10. Let g be the acceleration due to gravity at the surface of a planet of radius R. Which of the following is a dimensionally correct formula for the minimum kinetic energy K that a projectile of mass m must have at the planet's surface if the projectile is to escape from the planet's gravitational field?

    (A) $K = \sqrt{gR}$

    (B) $K = mgR$

    (C) $K = \frac{mg}{R}$

    (D) $K = m\sqrt{\frac{g}{R}}$

    (E) $K = gR$

Answers to AP Physics C: Mechanics Multiple-Choice Questions				
1 – D	3 – A	5 – A	7 – B	9 – A
2 – A	4 – E	6 – D	8 – C	10 – B

Sample Multiple-Choice Questions

The following multiple-choice questions provide a representative subset of those used in previous AP Chemistry Exams. There are two types of multiple-choice questions. The first type consists of five lettered headings followed by a list of numbered phrases. For each numbered phrase, the student is instructed to select the one heading that is most closely related to it. Each heading may be used once, more than once, or not at all in each group.

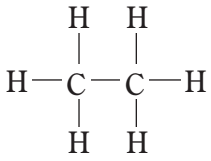
Questions 1–3 refer to atoms of the following elements.

(A) Lithium
(B) Carbon
(C) Nitrogen
(D) Oxygen
(E) Fluorine

1. In the ground state, have only 1 electron in each of the three *p* orbitals
2. Have the smallest atomic radius
3. Have the smallest value for first ionization energy

The majority of the multiple-choice questions consist of questions or incomplete statements followed by five suggested answers or completions. The student is instructed to select the one that is best in each case.

4. Which of the following species is NOT planar?
   (A) CO_3^{2-}
   (B) NO_3^-
   (C) ClF_3
   (D) BF_3
   (E) PCl_3



5. The hybridization of the carbon atoms in the molecule represented above can be described as
   (A) sp
   (B) sp^2
   (C) sp^3
   (D) dsp^2
   (E) d^2sp

6. The half-life of ^{55}Cr is about 2.0 hours. The delivery of a sample of this isotope from the reactor to a certain laboratory requires 12 hours. About what mass of such material should be shipped in order that 1.0 mg of ^{55}Cr is delivered to the laboratory?

   (A) 130 mg
   (B) 64 mg
   (C) 32 mg
   (D) 11 mg
   (E) 1.0 mg

7. At constant temperature, the behavior of a sample of a real gas more closely approximates that of an ideal gas as its volume is increased because the

   (A) collisions with the walls of the container become less frequent
   (B) average molecular speed decreases
   (C) molecules have expanded
   (D) average distance between molecules becomes greater
   (E) average molecular kinetic energy decreases

8. A sealed vessel contains 0.200 mol of oxygen gas, 0.100 mol of nitrogen gas, and 0.200 mol of argon gas. The total pressure of the gas mixture is 5.00 atm. The partial pressure of the argon is

   (A) 0.200 atm
   (B) 0.500 atm
   (C) 1.00 atm
   (D) 2.00 atm
   (E) 5.00 atm

9. Which of the following accounts for the fact that liquid CO_2 is <u>not</u> observed when a piece of solid CO_2 (dry ice) is placed on a lab bench?

   (A) The phase diagram for CO_2 has no triple point.
   (B) The normal boiling point of CO_2 is lower than its normal freezing point.
   (C) $CO_2(s)$ is a molecular solid.
   (D) The critical pressure for CO_2 is approximately 1 atm.
   (E) The triple point for CO_2 is above 1 atm.

10. If ΔG for a certain reaction has a negative value at 298 K, which of the following must be true?

    I. The reaction is exothermic.
    II. The reaction occurs spontaneously at 298 K.
    III. The rate of the reaction is fast at 298 K.

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

$$2\ SO_2(g) + O_2(g) \rightarrow 2\ SO_3(g)$$

11. A mixture of gases containing 0.20 mol of SO_2 and 0.20 mol of O_2 in a 4.0 L flask reacts to form SO_3. If the temperature is 25°C, what is the pressure in the flask after reaction is complete?

(A) $\frac{0.4(0.082)(298)}{4}$ atm

(B) $\frac{0.3(0.082)(298)}{4}$ atm

(C) $\frac{0.2(0.082)(298)}{4}$ atm

(D) $\frac{0.2(0.082)(25)}{4}$ atm

(E) $\frac{0.3(0.082)(25)}{4}$ atm

12. A solution prepared by mixing 10 mL of 1 *M* HCl and 10 mL of 1.2 *M* NaOH has a pH of

(A) 0 (B) 1 (C) 7 (D) 13 (E) 14

13. All of the following reactions can be defined as Lewis acid-base reactions EXCEPT

(A) $Al(OH)_3(s) + OH^-(aq) \rightarrow Al(OH)_4^-(aq)$
(B) $Cl_2(g) + H_2O(l) \rightarrow HOCl(aq) + H^+(aq) + Cl^-(aq)$
(C) $SnCl_4(s) + 2\ Cl^-(aq) \rightarrow SnCl_6^{2-}(aq)$
(D) $NH_4^+(g) + NH_2^-(g) \rightarrow 2\ NH_3(g)$
(E) $H^+(aq) + NH_3(aq) \rightarrow NH_4^+(aq)$

14. Which of the following represents a process in which a species is reduced?

(A) $Ca(s) \rightarrow Ca^{2+}(aq)$
(B) $Hg(l) \rightarrow Hg_2^{2+}(aq)$
(C) $Fe^{2+}(aq) \rightarrow Fe^{3+}(aq)$
(D) $NO_3^-(aq) \rightarrow NO(g)$
(E) $SO_3^{2-}(aq) \rightarrow SO_4^{2-}(aq)$

$$Cd^{2+}(aq) + 2\ e^- \rightleftarrows Cd(s) \quad E^\circ = -0.41\ V$$
$$Cu^+(aq) + e^- \rightleftarrows Cu(s) \quad E^\circ = +0.52\ V$$
$$Ag^+(aq) + e^- \rightleftarrows Ag(s) \quad E^\circ = +0.80\ V$$

15. Based on the standard electrode potentials given above, which of the following is the strongest reducing agent?

(A) $Cd(s)$ (B) $Cd^{2+}(aq)$ (C) $Cu(s)$ (D) $Ag(s)$ (E) $Ag^+(aq)$

16. A sample of $CaCO_3$ (molar mass 100. g) was reported as being 30. percent Ca. Assuming no calcium was present in any impurities, the percent of $CaCO_3$ in the sample is

(A) 30% (B) 40% (C) 70% (D) 75% (E) 100%

$$2\ Al(s) + 6\ HCl(aq) \rightarrow 2\ AlCl_3(aq) + 3\ H_2(g)$$

17. According to the reaction represented above, about how many grams of aluminum (atomic mass 27 g) are necessary to produce 0.50 mol of hydrogen gas at 25°C and 1.00 atm?

(A) 1.0 g
(B) 9.0 g
(C) 14 g
(D) 27 g
(E) 56 g

$$\ldots Cr_2O_7^{2-}(aq) + \ldots HNO_2(aq) + \ldots H^+(aq) \rightarrow \ldots Cr^{3+}(aq) + \ldots NO_3^-(aq) + \ldots H_2O(l)$$

18. When the equation for the redox reaction represented above is balanced and all coefficients are reduced to lowest whole-number terms, the coefficient for $H_2O(l)$ is

(A) 3 (B) 4 (C) 5 (D) 6 (E) 8

19. Which of the following equations represents the net reaction that occurs when gaseous hydrofluoric acid reacts with solid silicon dioxide?

(A) $2\ H^+(aq) + 2\ F^-(aq) + SiO_2(s) \rightarrow SiOF_2(s) + H_2O(l)$
(B) $4\ F^-(aq) + SiO_2(s) \rightarrow SiF_4(g) + 2\ O^{2-}(aq)$
(C) $4\ HF(g) + SiO_2(s) \rightarrow SiF_4(g) + 2\ H_2O(l)$
(D) $4\ HF(g) + SiO_2(s) \rightarrow Si(s) + 2\ F_2(g) + 2\ H_2O(l)$
(E) $2\ H_2F(g) + Si_2O_2(s) \rightarrow 2\ SiF(g) + 2\ H_2O(l)$

20. The ionization constant for acetic acid is 1.8×10^{-5}; that for hydrocyanic acid is 4×10^{-10}. In 0.1 *M* solutions of sodium acetate and sodium cyanide, it is true that

(A) $[H^+]$ equals $[OH^-]$ in each solution
(B) $[H^+]$ exceeds $[OH^-]$ in each solution
(C) $[H^+]$ of the sodium acetate solution is less than that of the sodium cyanide solution
(D) $[OH^-]$ of the sodium acetate solution is less than that of the sodium cyanide solution
(E) $[OH^-]$ for the two solutions is the same

$$HCl > HC_2H_3O_2 > HCN > H_2O > NH_3$$

21. Five acids are listed above in the order of decreasing acid strength. Which of the following reactions must have an equilibrium constant with a value less than 1?

(A) $HCl(aq) + CN^-(aq) \rightleftarrows HCN(aq) + Cl^-(aq)$
(B) $HCl(aq) + H_2O(l) \rightleftarrows H_3O^+(aq) + Cl^-(aq)$
(C) $HC_2H_3O_2(aq) + OH^-(aq) \rightleftarrows C_2H_3O_2^-(aq) + H_2O(l)$
(D) $H_2O(aq) + NH_2^-(aq) \rightleftarrows NH_3(aq) + OH^-(aq)$
(E) $HCN(aq) + C_2H_3O_2^-(aq) \rightleftarrows HC_2H_3O_2(aq) + CN^-(aq)$

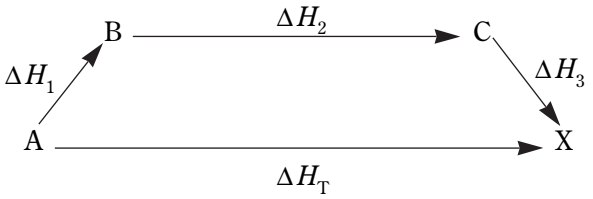
Experiment	*Initial* [X] *(mol L^{-1})*	*Initial* [Y] *(mol L^{-1})*	*Initial Rate of Formulation of Z (mol L^{-1} min^{-1})*
1	0.10	0.30	4.0×10^{-4}
2	0.20	0.60	1.6×10^{-3}
3	0.20	0.30	4.0×10^{-4}

22. The data in the table above were obtained for the reaction X + Y → Z. Which of the following is the rate law for the reaction?

(A) Rate = $k[X]^2$
(B) Rate = $k[Y]^2$
(C) Rate = $k[X][Y]$
(D) Rate = $k[X]^2[Y]$
(E) Rate = $k[X][Y]^2$

$$A \rightarrow X$$

23. The enthalpy change for the reaction represented above is ΔH_T. This reaction can be broken down into a series of steps as shown in the diagram:



A relationship that must exist among the various enthalpy changes is

(A) $\Delta H_T - \Delta H_1 - \Delta H_2 - \Delta H_3 = 0$
(B) $\Delta H_T + \Delta H_1 + \Delta H_2 + \Delta H_3 = 0$
(C) $\Delta H_3 - (\Delta H_1 + \Delta H_2) = \Delta H_T$
(D) $\Delta H_2 - (\Delta H_3 + \Delta H_1) = \Delta H_T$
(E) $\Delta H_T + \Delta H_2 = \Delta H_1 + \Delta H_3$

24. What formula would be expected for a binary compound of barium and nitrogen?

(A) Ba_3N_2 (B) Ba_2N_3 (C) Ba_2N (D) BaN_2 (E) BaN

25. All of the following statements about the nitrogen family of elements are true EXCEPT:

(A) It contains both metals and nonmetals.
(B) The electronic configuration of the valence shell of the atom is ns^2np^3.
(C) The only oxidation states exhibited by members of this family are –3, 0, +3, +5.
(D) The atomic radii increase with increasing atomic number.
(E) The boiling points increase with increasing atomic number.

26. Of the following organic compounds, which is LEAST soluble in water at 298 K?

(A) CH_3OH, methanol
(B) $CH_3CH_2CH_2OH$, l-propanol
(C) C_6H_{14}, hexane
(D) $C_6H_{12}O_6$, glucose
(E) CH_3COOH, ethanoic (acetic) acid

27. Which of the following salts forms a basic solution when dissolved in water?

(A) NaCl
(B) $(NH_4)_2SO_4$
(C) $CuSO_4$
(D) K_2CO_3
(E) NH_4NO_3

28. The molecular mass of a substance can be determined by measuring which of the following?

I. Osmotic pressure of a solution of the substance
II. Freezing point depression of a solution of the substance
III. Density of the gas (vapor) phase of the substance

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

29. The table below summarizes the reactions of a certain unknown solution when treated with bases.

		Results	
Sample	*Reagent*	*Limited Amount of Reagent*	*Excess Reagent*
I	NaOH (*aq*)	White precipitate	Precipitate dissolves
II	NH_3(*aq*)	White precipitate	White precipitate

Which of the following metallic ions could be present in the unknown solution?

(A) Ca^{2+} (*aq*)
(B) Zn^{2+} (*aq*)
(C) Ni^{2+} (*aq*)
(D) Al^{3+} (*aq*)
(E) Ag^{+} (*aq*)

Answers to Multiple-Choice Questions

1 – C	7 – D	13 – B	19 – C	25 – C
2 – E	8 – D	14 – D	20 – D	26 – C
3 – A	9 – E	15 – A	21 – E	27 – D
4 – E	10 – B	16 – D	22 – B	28 – E
5 – C	11 – B	17 – B	23 – A	29 – D
6 – B	12 – D	18 – B	24 – A	

Sample Questions for the AP Physics 2 Exam

Multiple-Choice Questions

NOTE: *To simplify calculations, you may use g = 10 m/s² 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 then fill in the corresponding circle on the answer sheet.

Questions 1–3 refer to the following material.

An isolated, neutral lambda particle $\left(\Lambda^0\right)$ is moving to the right with speed *v*. It then decays into a proton and a pion $\left(\Lambda^0 \rightarrow p^+ + \pi^-\right)$. The following are the masses of the three particles:

Lambda: $1115.7\,MeV/c^2$

Proton: $938.3\,MeV/c^2$

Pion: $139.6\,MeV/c^2$

1. How much energy is released when the Λ^0 decays?

   (A) 2193.6 MeV

   (B) 1914.4 MeV

   (C) 317.0 MeV

   (D) 37.8 MeV

Enduring Understanding	Learning Objective	Science Practice
4.C: Interactions with other objects or systems can change the total energy of a system.	**4.C.4.1:** The student is able to apply mathematical routines to describe the relationship between mass and energy and apply this concept across domains of scale.	**2.2:** The student can *apply mathematical routines* to quantities that describe natural phenomena.

2. Which of the following indicates how the total linear momentum of the Λ^0 particles after the decay compares to the linear momentum of the before the decay and explains why?

   (A) The momentum is in the same direction but has a smaller magnitude because the proton and pion have opposite charges and attract each other.

   (B) The momentum is in the same direction but has a smaller magnitude because the proton and pion are emitted in opposite directions.

   (C) The momentum is in the same direction and has the same magnitude because no external force acts on the system of particles.

   (D) The momentum is in the same direction and has the same magnitude because the work done by the strong force is greater than the energy emitted during the decay.

3. At some later time, the proton and pion are both moving to the right in the plane of the page when they enter a magnetic field directed out of the page. Which of the following describes the directions of the magnetic forces on the proton and pion at the instant they enter the field?

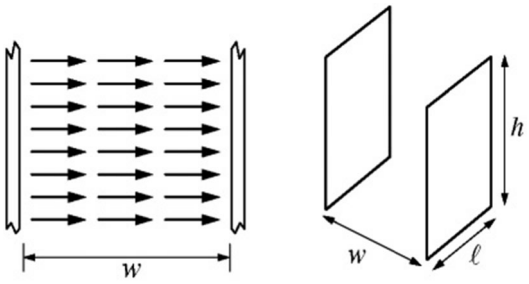
   (A) Proton: toward the top of the page Pion: toward the top of the page

   (B) Proton: toward the top of the page Pion: toward the bottom of the page

   (C) Proton: toward the bottom of the page Pion: toward the bottom of the page

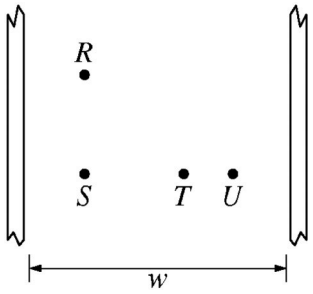
   (D) Proton: toward the bottom of the page Pion: toward the top of the page

Questions 4–7 refer to the following material.



Note: Figure not drawn to scale.

The figure above on the left represents the horizontal electric field near the center of two large, vertical parallel plates near Earth's surface. The plates have height h and length ℓ, and they are separated by a distance w, as shown on the right. The field has magnitude E. A small object with mass m = and charge $+q$, where $m = qE / g$, is released from rest at a point midway between the plates.



4. Points R, S, T, and U are located between the plates as shown in the figure above, with points R and T equidistant from point S. Let V_{RS} , V_{ST} , V_{TU} , and V_{RU} be the magnitudes of the electric potential differences between the pairs of points. How do the magnitudes of these potential differences compare?

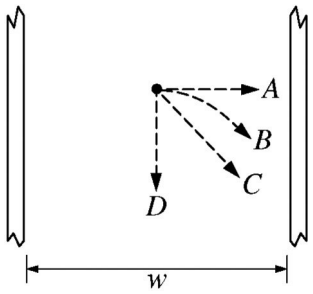
   (A) $V_{RU} > V_{ST} > V_{TU} > V_{RS}$

   (B) $V_{RU} > (V_{RS} = V_{ST} > V_{TU}$

   (C) $V_{Rs} > V_{TU} > V_{ST} > V_{RU}$

   (D) $V_{TU} > (V_{RS} = V_{ST}) > V_{RU}$

Enduring Understanding	Learning Objective	Science Practice
2.C: An electric field is caused by an object with electric charge.	**2.C.5.2:** The student is able to calculate the magnitude and determine the direction of the electric field between two electrically charged parallel plates, given the charge of each plate, or the electric potential difference and plate separation.	**2.2:** The student can *apply mathematical routines* to quantities that describe natural phenomena.



5. After the object is released from rest, which of the paths shown in the figure above is a possible trajectory for the object?

   (A) A

   (B) B

   (C) C

   (D) D

6. Under which of the following new conditions could the gravitational force on the object be neglected?

   (A) $h >> w$

   (B) $q >> m$

   (**C**) $qE >> mg$

   (D) $Eh >> Ew$

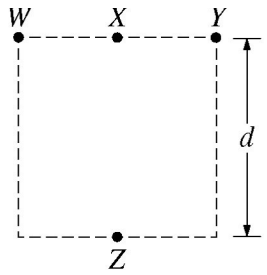
7. The speed of a proton moving in an electric field changes from v_i to v_f over a certain time interval. Let the mass and charge of the proton be denoted as m_p and e. Through what potential difference did the proton move during the interval?

   (A) $\frac{m_p}{2}\left(v_f^2 - 2v_i^2\right)$

   (B) $\frac{m_p}{2e}\left(v_f^2 - v_i^2\right)$

   (C) $\frac{m_p}{2}\left(v_f - v_i\right)$

   (D) $\frac{m_p}{2e}\left(v_f - v_i\right)$



8. Four objects, each with charge +q, are held fixed on a square with sides of length d, as shown in the figure above. Objects X and Z are at the midpoints of the sides of the square. The electrostatic force exerted by object W on object X is F. What is the magnitude of the net force exerted on object X by objects W, Y, and Z ?

   (A) $\frac{F}{4}$

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

   (C) $\frac{9F}{4}$

   (D) $3F$

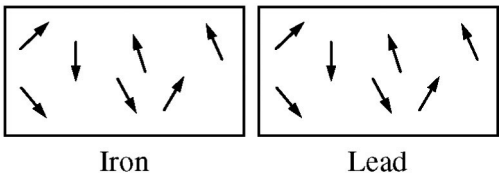
9. Isolines of potential are drawn for the gravitational field of the Sun-Mercury system. The pattern of the isolines is identical to the pattern of equipotential lines for a system of two electrically charged objects with which of the following properties?

   (A) The charges have the same sign and the same magnitude.

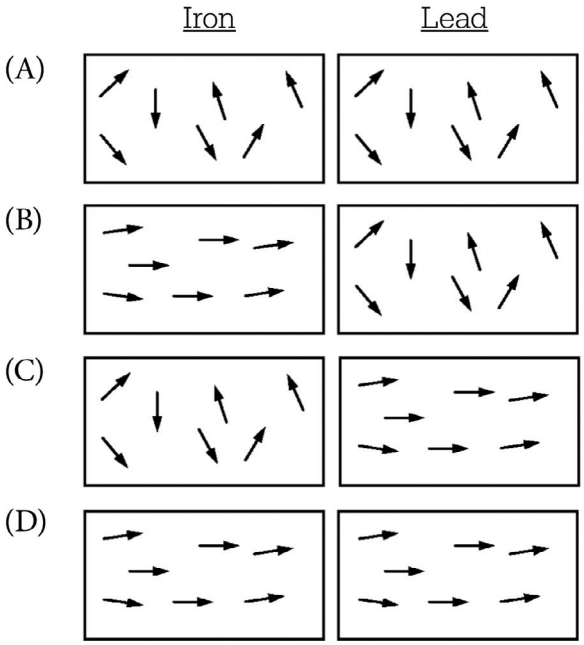
   (B) The charges have the same sign and different magnitudes.

   (C) The charges have opposite signs and the same magnitude.

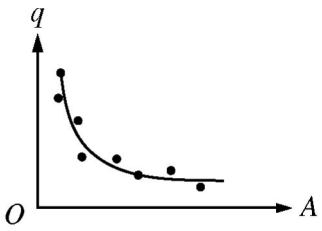
   (D) The charges have opposite signs and different magnitudes.



10. The figure above represents the random orientations of the magnetic dipoles in a block of iron and a block of lead. Iron is ferromagnetic and lead is diamagnetic. The two blocks are placed in a magnetic field that points to the right. Which of the following best represents the orientations of the dipoles when the field is present?



Enduring Understandings	Learning Objectives	Science Practices
2.D: A magnetic field is caused by a magnet or a moving electrically charged object. Magnetic fields observed in nature always seem to be produced either by moving charged objects or by magnetic dipoles or combinations of dipoles and never by single poles.	**2.D.3.1:** The student is able to describe the orientation of a magnetic dipole placed in a magnetic field in general and the particular cases of a compass in the magnetic field of the Earth and iron filings surrounding a bar magnet.	**1.2:** The student can *describe representations and models* of natural or man-made phenomena and systems in the domain.
4.E: The electric and magnetic properties of a system can change in response to the presence of, or changes in, other objects or systems.	**4.E.1.1:** The student is able to use representations and models to qualitatively describe the magnetic properties of some materials that can be affected by magnetic properties of other objects in the system.	**1.4:** The student can *use representations and models* to analyze situations or solve problems qualitatively and quantitatively.



11. Students are performing an experiment to determine how changing the area of the plates of a parallel-plate capacitor affects its behavior in a circuit. They connect a capacitor with plate area A to a battery and allow it to become fully charged. They take measurements that they believe will allow them to calculate the charge q on one plate of the capacitor. The students then repeat the procedure with other capacitors. The capacitors each have a different plate area but are otherwise identical. The students plot the calculated charge q as a function of plate area A. Their results, including a best fit to the data, are represented above. Is this graph a reasonably accurate representation of the relationship between q and A?

    (A) Yes, because the relationship should result in a graph that is curved and decreasing.

    (B) No, because the relationship should result in a graph that is linear and decreasing.

    (C) No, because the relationship should result in a graph that is linear and increasing.

    (D) No, because the relationship should result in a graph that is curved and increasing.

12. Some students experimenting with an uncharged metal sphere want to give the sphere a net charge using a charged aluminum pie plate. Which of the following steps would give the sphere a net charge of the same sign as the pie plate?

    (A) Bringing the pie plate close to, but not touching the metal sphere, then moving the pie plate away

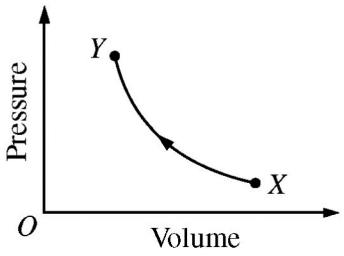
    (B) Bringing the pie plate close to, but not touching, the metal sphere, then momentarily touching a grounding wire to the metal sphere

    (C) Bringing the pie plate close to, but not touching, the metal sphere, then momentarily touching a grounding wire to the pie plate

    (D) Touching the pie plate to the metal sphere

13. An ideal fluid is flowing with a speed of 12cm/s through a pipe of diameter 5 cm. The pipe splits into three smaller pipes, each with a diameter of 2 cm. What is the speed of the fluid in the smaller pipes?

(A) 4cm/s
(B) 12cm/s
(C) 25cm/s
(D) 75cm/s



14. The graph above shows the pressure as a function of volume for a sample of gas that is taken from state X to state Y at constant temperature. Which of the following indicates the sign of the work done on the gas, and whether thermal energy is absorbed or released by the gas during this process?

	Work done	Thermal energy
(A)	Positive	Absorbed
(B)	Positive	Released
(C)	Negative	Absorbed
(D)	Negative	Released

15. Two samples of ideal gas in separate containers have the same number of molecules and the same temperature, but the molecular mass of gas *X* is greater than that of gas *Y*. Which of the following correctly compares the average speed of the molecules of the gases and the average force the gases exert on their respective containers?

	Average speed of Molecules	Average Force on container
(A)	Greater for gas *X*	Greater for gas *X*
(B)	Greater for gas *X*	The forces cannot be compared without knowing the volumes of the gases.
(C)	Greater for gas *Y*	Greater for gas *Y*
(D)	Greater for gas *Y*	The forces cannot be compared without knowing the volumes of the gases.

16. Three different gas samples that have the same number of molecules and are at room temperature are kept at different pressures. A lab technician has determined the molecular mass of each gas and recorded the pressure and molecular mass of each sample in the table below.

Gas	Molecular Mass (u)	Pressure (¥100kPa)
X	2.0	6.0
Y	4.0	12
Z	40	1.0

Which of the following ranks the density ρ of the gas samples?

(A) $\rho_x = \rho_y > \rho_Z$

(B) $\rho_y > \rho_Z > \rho_X$

(C) $\rho_Z > \rho_X = \rho_Y$

(D) $\rho_Z > \rho_Y > \rho_X$

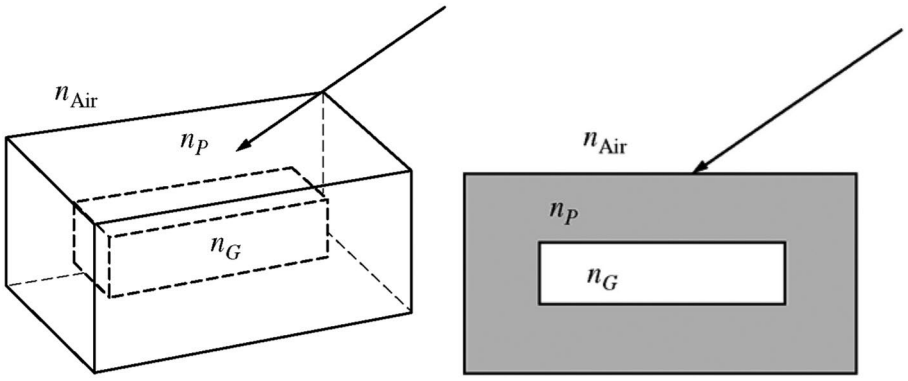
17. Light from a source that produces a single frequency passes through a single slit *A*. The diffraction pattern on a screen is observed. Slit *A* is then replaced by slit *B*, and the new pattern is observed to have fringes that are more closely spaced than those in the first pattern. Which of the following is a possible explanation for why the spacings are different?

(A) Slit *A* is wider than slit *B*.

(B) Slit *B* is wider than slit *A*.

(C) The distance between the light source and the slit is greater for slit *A* than for slit *B*.

(D) The distance between the light source and the slit is greater for slit *B* than for slit *A*.



18. Students in a lab group are given a plastic block with a hollow space in the middle, as shown in the figures above. The index of refraction n_P of the plastic is known. The hollow space is filled with a gas, and the students are asked to collect the data needed to find the index of refraction n_G of the gas. The arrow represents a light beam that they shine into the plastic. They take the following set of measurements:

Angle of incidence of the light in the air above the plastic block	30°
Angle of refraction of the beam as it enters the plastic from the air	45°
Angle of refraction of the beam as it enters the plastic from the gas	45°

The three measurements are shared with a second lab group. Can the second group determine a value of n_G from only this data?

(A) Yes, because they have information about the beam in air and in the plastic above the gas.

(B) Yes, because they have information about the beam on both sides of the gas.

(C) No, because they need additional information to determine the angle of the beam in the gas.

(D) No, because they do not have multiple data points to analyze.

19. The ground state of a certain type of atom has energy $-E_0$. What is the wavelength of a photon with enough energy to ionize an atom in the ground state and give the ejected electron a kinetic energy of $2E_0$?

(A) $\frac{hc}{3E_0}$

(B) $\frac{hc}{2E_0}$

(C) $\frac{hc}{E_0}$

(D) $\frac{2hc}{E_0}$

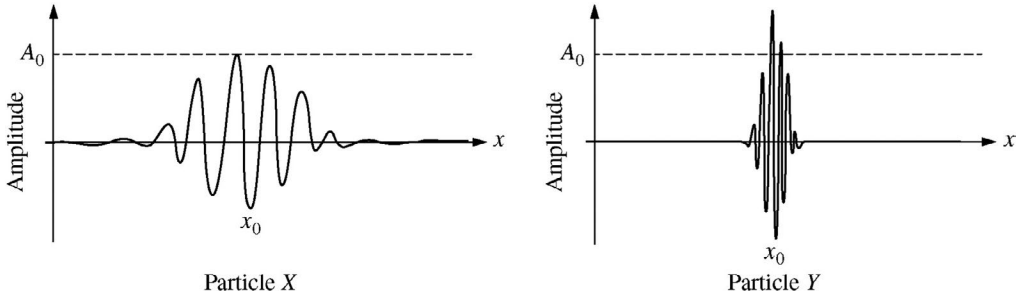
20. A hypothetical one-electron atom in its highest excited state can only emit photons of energy $2E$, $3E$, and $5E$. Which of the following is a possible energy-level diagram for the atom?

(A)
_____ $5E$
_____ $3E$
_____ 0

(B)
_____ $3E$
_____ $2E$
_____ 0

(C)
_____ $5E$
_____ $3E$
_____ $2E$
_____ 0

(D)
_____ $10E$
_____ $8E$
_____ $5E$
_____ 0



21. The figure above shows graphical representations of the wave functions of two particles, X and Y, that are moving in the positive x-direction. The maximum amplitude of particle X's wave function is A_0. Which particle has a greater probability of being located at position x_0 at this instant, and why?

(A) Particle X, because the wave function of particle X spends more time passing through x_0 than the wave function of particle Y

(B) Particle X, because the wave function of particle X has a longer wavelength than the wave function of particle Y

(C) Particle Y, because the wave function of particle Y is narrower than the wave function of particle X

(D) Particle Y, because the wave function of particle Y has a greater amplitude near x_0 than the wave function of particle X

22. On a day that is warm and sunny, a car is parked in a location where there is no shade. The car's windows are closed. The air inside the car becomes noticeably warmer than the air outside. Which of the following factors contribute to the higher temperature? **Select two answers.**

(A) Hotter air rises to the roof of the car and cooler air falls to the floor.

(B) The body of the car insulates the air inside the car.

(C) Electromagnetic radiation from the Sun enters the car and is absorbed by the materials inside.

(D) The body of the car reflects electromagnetic radiation.

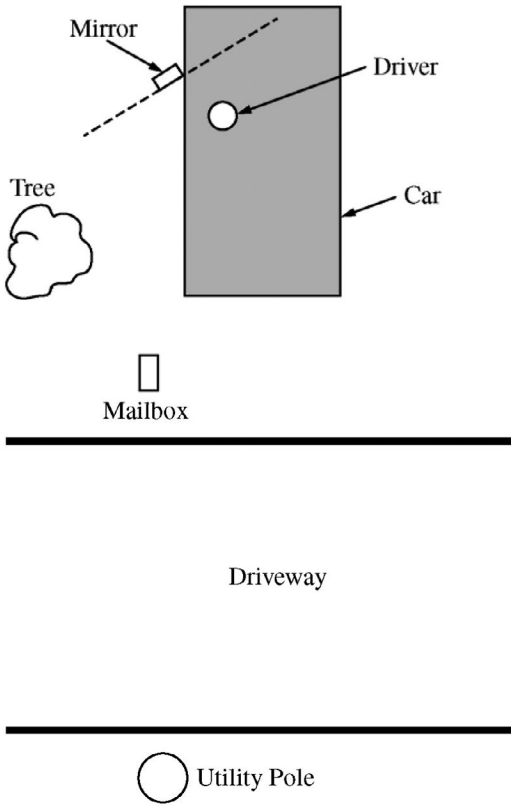
23. A fixed amount of ideal gas is kept in a container of fixed volume. The absolute pressure P, in pascals, of the gas is plotted as a function of its temperature T, in degrees Celsius. Which of the following are properties of a best fit curve to the data? **Select two answers.**

(A) Having a positive slope

(B) Passing through the origin

(C) Having zero pressure at a certain negative temperature

(D) Approaching zero pressure as temperature approaches infinity



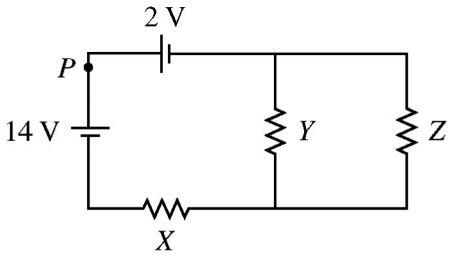
24. A driver is backing a car off a lawn into a driveway while using the side-view mirror to check for obstacles. The figure above shows a top view of the car and some objects near the car. The mirror is a plane mirror, and the dashed line shows the angle of its plane. Which of the following should the driver be able to see in the mirror by just turning her head without moving her head from the position shown? **Select two answers.**

(A) Herself

(B) The tree

(C) The mailbox

(D) The utility pole



25. The figure above shows a circuit containing two batteries and three identical resistors with resistance *R*. Which of the following changes to the circuit will result in an increase in the current at point *P* ? **Select two answers.**

(A) Reversing the connections to the 14 V battery

(B) Removing the 2 V battery and connecting the wires to close the left loop

(C) Rearranging the resistors so all three are in series

(D) Removing the branch containing resistor *Z*

Answers to Multiple-Choice Questions

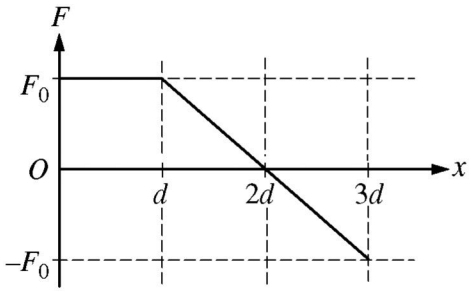
1. D	14. B
2. C	15. D
3. D	16. B
4. A	17. B
5. C	18. C
6. C	19. A
7. B	20. A
8. A	21. D
9. B	22. B, C
10. B	23. A, C
11. C	24. C, D
12. D	25. A, B
13. C	

Sample Questions for the AP Physics 1 Exam

Multiple-Choice Questions

NOTE: *To simplify calculations, you may use $g = 10\ m/s^2$ 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 then fill in the corresponding circle on the answer sheet.



1. An object is moving in the positive x-direction while a net force directed along the x-axis is exerted on the object. The figure above shows the force as a function of position. What is the net work done on the object over the distance shown?

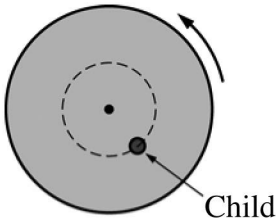
   (A) $F_0 d$

   (B) $3F_0 d / 2$

   (C) $2F_0 d$

   (D) $4F_0 d$

Enduring Understanding	Learning Objective	Science Practices
5.B: The energy of a system is conserved.	**5.B.5.3:** The student is able to predict and calculate from graphical data the energy transfer to or work done on an object or system from information about a force exerted on the object or system through a distance.	**1.4:** The student can *use representations and models* to analyze situations or solve problems qualitatively and quantitatively. **2.2:** The student can *apply mathematical routines* to quantities that describe natural phenomena.



Top View

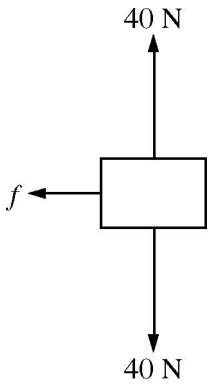
2. The diagram above shows a top view of a child of mass M on a circular platform of mass $2M$ that is rotating counterclockwise. Assume the platform rotates without friction. Which of the following describes an action by the child that will increase the angular speed of the platform-child system and gives the correct reason why?

   (A) The child moves toward the center of the platform, increasing the total angular momentum of the system.

   (B) The child moves toward the center of the platform, decreasing the rotational inertia of the system.

   (C) The child moves away from the center of the platform, increasing the total angular momentum of the system.

   (D) The child moves away from the center of the platform, decreasing the rotational inertia of the system.



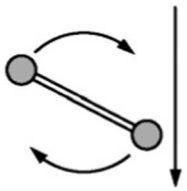
3. The figure above shows the forces exerted on a block that is sliding on a horizontal surface: the gravitational force of 40 N, the 40 N normal force exerted by the surface, and a frictional force exerted to the left. The coefficient of friction between the block and the surface is 0.20. The acceleration of the block is most nearly

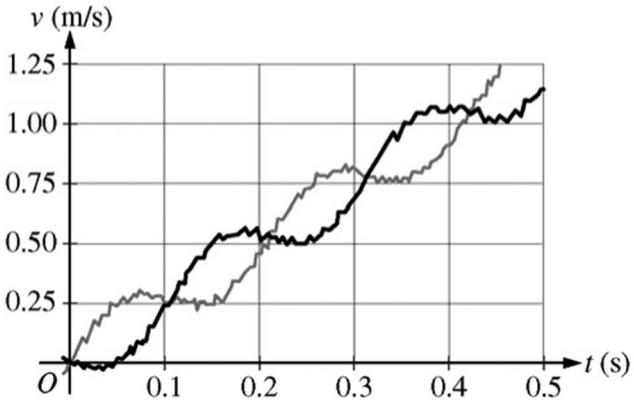
   (A) $1.0\ \text{m/s}^2$ to the right

   (B) $1.0\ \text{m/s}^2$ to the left

   (C) $2.0\ \text{m/s}^2$ to the right

   (D) $2.0\ \text{m/s}^2$ to the left





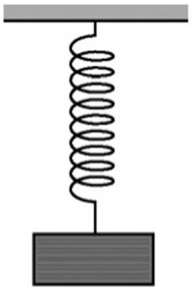
4. A student on another planet has two identical spheres, each of mass 0.6 kg, attached to the ends of a rod of negligible mass. The student gives the assembly a rotation in the vertical plane and then releases it so it falls, as shown in the top figure above. Sensors record the vertical velocity of the two spheres, and the data is shown in the graph of velocity v as a function of time t. Another student wants to calculate the assembly's angular speed and the change in the linear momentum of the center of mass of the assembly between 0 s and 0.3 s. Which of these quantities can be determined using the graph?

   (A) Angular speed only

   (B) Change in linear momentum only

   (C) Angular speed and change in linear momentum

   (D) Neither of these quantities can be determined using the graph.



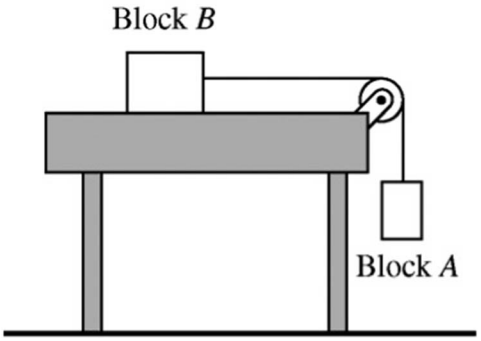
5. A block of known mass hanging from an ideal spring of known spring constant is oscillating vertically. A motion detector records the position, velocity, and acceleration of the block as a function of time. Which of the following indicates the measured quantities that are sufficient to determine whether the net force exerted on the block equals the vector sum of the individual forces?

   (A) Acceleration only

   (B) Acceleration and position only

   (C) Acceleration and velocity only

   (D) Acceleration, position, and velocity



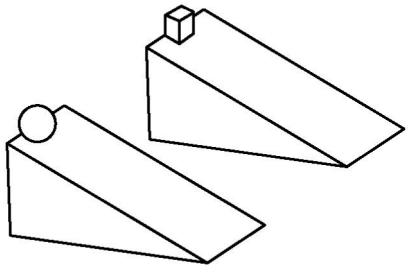
6. Block *A* hangs from a light string that passes over a light pulley and is attached to block *B*, which is on a level horizontal frictionless table, as shown above. Students are to determine the mass of block *B* from the motion of the two-block system after it is released from rest. They plan to measure the time block *A* takes to reach the floor. The students must also take which of the following measurements to determine the mass of block *B*?

   (A) Only the mass of block *A*

   (B) Only the distance block *A* falls to reach the floor

   (C) Only the mass of block *A* and the distance block *A* falls to reach the floor

   (D) The mass of block *A*, the distance block *A* falls to reach the floor, and the radius of the pulley



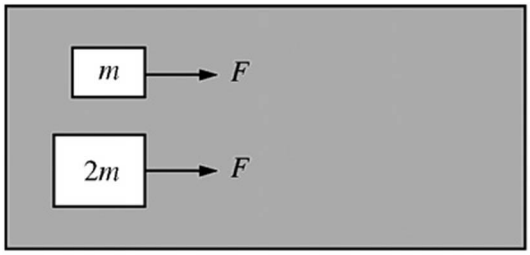
7. Two objects are released from rest at the top of ramps with the same dimensions, as shown in the figure above. The sphere rolls down one ramp without slipping. The small block slides down the other ramp without friction. Which object reaches the bottom of its ramp first, and why?

   (A) The sphere, because it gains rotational kinetic energy, but the block does not

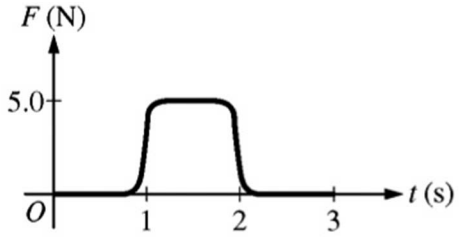
   (B) The sphere, because it gains mechanical energy due to the torque exerted on it, but the block does not

   (C) The block, because it does not lose mechanical energy due to friction, but the sphere does

   (D) The block, because it does not gain rotational kinetic energy, but the sphere does



Top View



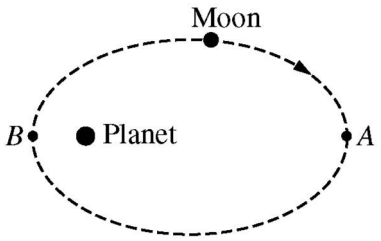
8. Two blocks, of mass m and $2m$, are initially at rest on a horizontal frictionless surface. A force F is exerted individually on each block, as shown above. The graph shows how F varies with time t. Which block has the greatest average power provided to it between $t = 0$ s and $t = 3$ s?

   (A) The block of mass m

   (B) The block of mass $2m$

   (C) Both blocks have the same power provided to them.

   (D) It cannot be determined without knowing the ratio of the maximum force to the mass m.



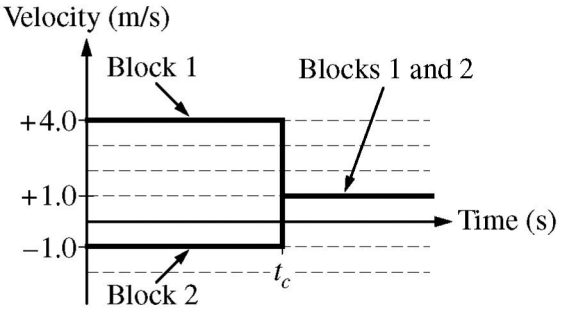
9. A moon is in an elliptical orbit about a planet as shown above. At point A the moon has speed u_A and is at distance R_A from the planet. At point B the moon has speed u_B. Which of the following explains a correct method for determining the distance of the moon from the planet at point B in terms of the given quantities?

   (A) Conservation of angular momentum, because the gravitational force exerted by the moon on the planet is the same as that exerted by the planet on the moon

   (B) Conservation of angular momentum, because the gravitational force exerted on the moon is always directed toward the planet

   (C) Conservation of energy, because the gravitational force exerted on the moon is always directed toward the planet

   (D) Conservation of energy, because the gravitational force exerted by the moon on the planet is the same as that exerted by the planet on the moon



Block 1 of mass m_1 and block 2 of mass m_2 are sliding along the same line on a horizontal frictionless surface when they collide at time t_c. The graph above shows the velocities of the blocks as a function of time.

10. Which block has the greater mass, and what information indicates this?

   (A) Block 1, because it had a greater speed before the collision.

   (B) Block 1, because the velocity after the collision is in the same direction as its velocity before the collision.

   (C) Block 2, because it had a smaller speed before the collision.

   (D) Block 2, because the final velocity is closer to the initial velocity of block 2 than it is to the initial velocity of block 1.

11. How does the kinetic energy of the two-block system after the collision compare with its kinetic energy before the collision, and why?

    (A) It is less, because the blocks have the same velocity after the collision, so some of their kinetic energy was transformed into internal energy.

    (B) It is less, because the blocks have velocities in opposite directions before the collision, so some of their kinetic energy cancels.

    (C) It is the same, because the collision was instantaneous, so the effect of external forces during the collision is negligible.

    (D) It is the same, because the blocks have the same velocity after the collision, and there is no friction acting on them.

12. Which of the following is true of the motion of the center of mass of the two-block system during the time shown?

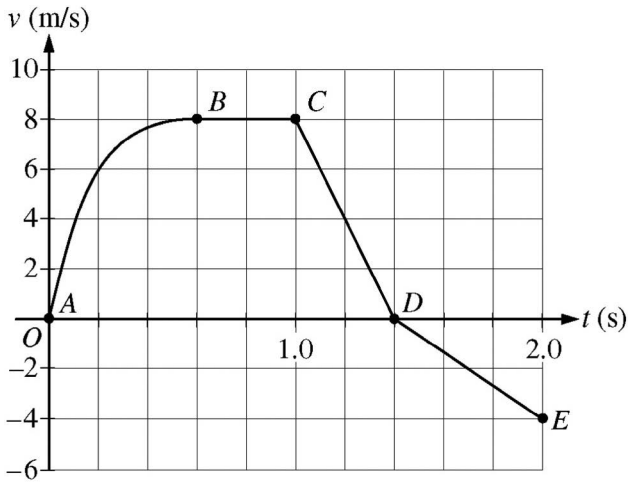
    (A) The center of mass does not move because the blocks are moving in opposite directions before the collision.

    (B) The center of mass moves at a constant velocity of +1.0 m/s because there is no friction acting on the system.

    (C) The center-of-mass velocity starts out greater than +1.0 m/s but decreases to +1.0 m/s during the collision because the collision is inelastic.

    (D) The center-of-mass velocity increases as the blocks get closer together, and then becomes constant after the collision.

Questions 13–15 refer to the following information.



A cart is constrained to move along a straight line. A varying net force along the direction of motion is exerted on the cart. The cart's velocity v as a function of time t is shown in the graph above. The five labeled points divide the graph into four sections.

13. Which of the following correctly ranks the magnitude of the average acceleration of the cart during the four sections of the graph?

    (A) $a_{CD} > a_{AB} > a_{BC} > a_{DE}$

    (B) $a_{BC} > a_{AB} > a_{CD} > a_{DE}$

    (C) $a_{AB} > a_{BC} > a_{DE} > a_{CD}$

    (D) $a_{CD} > a_{AB} > a_{DE} > a_{BC}$

14. For which segment does the cart move the greatest distance?

    (A) *AB*

    (B) *BC*

    (C) *CD*

    (D) *DE*

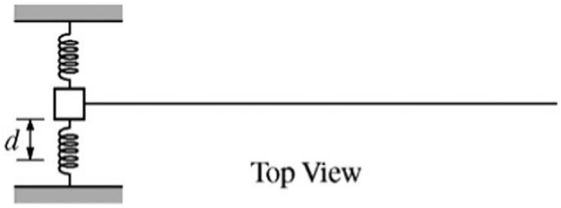
15. During some part of the motion, the work done on the cart is negative. What feature of the motion indicates this?

    (A) The speed is increasing.

    (B) The speed is decreasing.

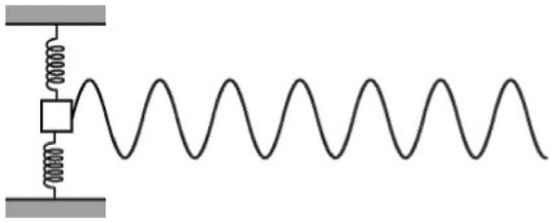
    (C) The acceleration is positive.

    (D) The acceleration is negative.

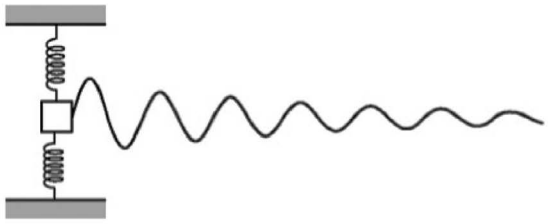


16. The figure above shows a block on a horizontal surface attached to two springs whose other ends are fixed to walls. A light string attached to one side of the block initially lies straight across the surface, as shown. The other end of the string is free to move. There is significant friction between the block and the surface but negligible friction between the string and the surface. The block is displaced a distance d and released from rest. Which of the following best represents the shape of the string a short time later?

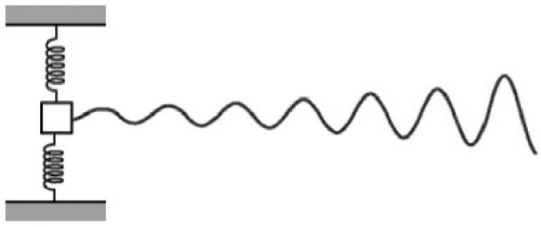
(A)



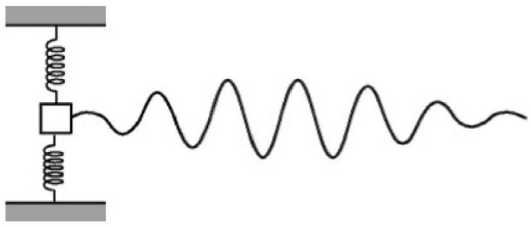
(B)



(C)



(D)



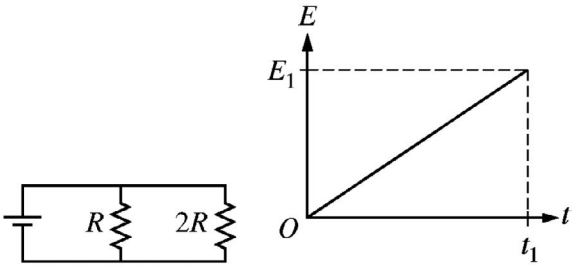
17. Two massive, positively charged particles are initially held a fixed distance apart. When they are moved farther apart, the magnitude of their mutual gravitational force changes by a factor of n. Which of the following indicates the factor by which the magnitude of their mutual electrostatic force changes?

(A) $1/n^2$

(B) $1/n$

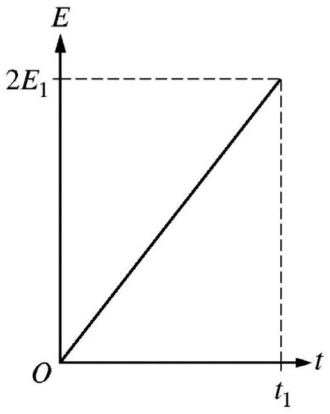
(C) n

(D) n^2

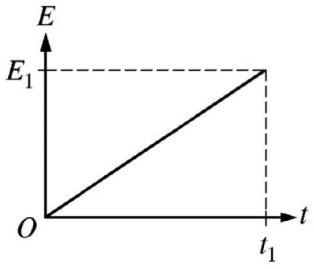


18. The circuit shown above contains two resistors of resistance R and $2R$. The graph shows the total energy E dissipated by the smaller resistance as a function of time. Which of the following shows the corresponding graph for the larger resistance?

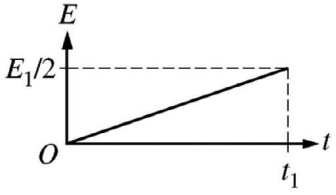
(A)



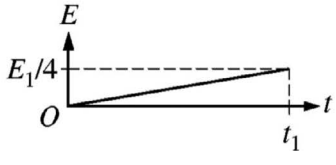
(B)

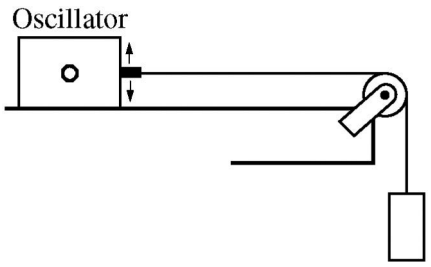


(C)



(D)





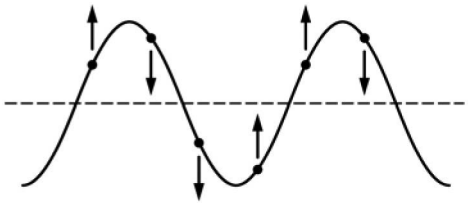
19. A student connects one end of a string with negligible mass to an oscillator. The other end of the string is passed over a pulley and attached to a suspended weight, as shown above. The student finds that a standing wave with one antinode is formed on the string when the frequency of the oscillator is f_0. The student then moves the oscillator to shorten the horizontal segment of string to half its original length. At what frequency will a standing wave with one antinode now be formed on the string?

(A) $f_0 / 2$

(B) f_0

(C) $2f_0$

(D) There is no frequency at which a standing wave will be formed.



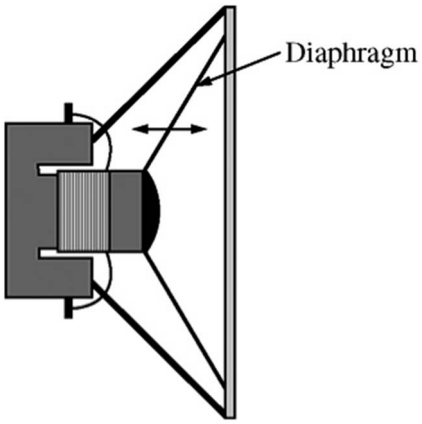
20. The figure above shows a portion of a periodic wave on a string at a particular moment in time. The vertical arrows indicate the direction of the velocity of some points on the string. Is the wave moving to the right or to the left?

(A) To the right

(B) To the left

(C) Neither direction; the wave is a standing wave, so it is not moving.

(D) Either direction; the figure is consistent with wave motion to the right or to the left.



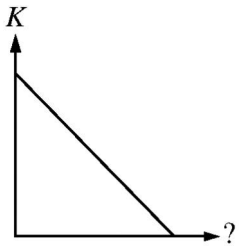
21. A radio speaker produces sound when a membrane called a diaphragm vibrates, as shown above. A person turns up the volume on the radio. Which of the following aspects of the motion of a point on the diaphragm must increase?

    (A) The maximum displacement only

    (B) The average speed only

    (C) Both the maximum displacement and the average speed

    (D) Neither the maximum displacement nor the average speed



22. A block is given a short push and then slides with constant friction across a horizontal floor. The graph above shows the kinetic energy of the block after the push ends as a function of an unidentified quantity. The quantity could be which of the following? **Select two answers.**

    (A) Time elapsed since the push

    (B) Distance traveled by the block

    (C) Speed of the block

    (D) Magnitude of the net work done on the block

23. A musician stands outside in a field and plucks a string on an acoustic guitar. Standing waves will most likely occur in which of the following media? **Select two answers.**

(A) The guitar string

(B) The air inside the guitar

(C) The air surrounding the guitar

(D) The ground beneath the musician

24. A 0.2 kg rock is dropped into a lake from a few meters above the surface of the water. The rock reaches terminal velocity in the lake after 5 s in the water. During the final 3 s of its descent to the lake bottom, the rock moves at a constant speed of 4 m/s. Which of the following can be determined from the information given? **Select two answers.**

(A) The speed of the rock as it enters the lake

(B) The distance the rock travels in the first 5 s of its descent in the water

(C) The acceleration of the rock 2 s before it reaches the lake bottom

(D) The change in potential energy of the rock-Earth-water system during the final 3 s of the rock's descent

25. In an experiment, three microscopic latex spheres are sprayed into a chamber and become charged with $+3e$, $+5e$, and $-3e$, respectively. Later, all three spheres collide simultaneously and then separate. Which of the following are possible values for the final charges on the spheres? Select two answers.

	X	Y	Z
(A)	$+4e$	$-4e$	$+5e$
(B)	$+4e$	$+4.5e$	$+4.5e$
(C)	$+5e$	$-8e$	$+7e$
(D)	$+6e$	$+6e$	$-7e$

Answers to Multiple-Choice Questions

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