

1999 AAPT PHYSICS OLYMPIAD

Entia non multiplicanda sunt praeter necessitatem

1999 MULTIPLE CHOICE SCREENING TEST 30 QUESTIONS - 40 MINUTES

INSTRUCTIONS

DO NOT OPEN THIS TEST UNTIL YOU ARE TOLD TO BEGIN

This test contains 30 multiple choice questions. Your answer to each question must be marked on the optical mark answer sheet that accompanies the test. Only the boxes preceded by numbers 1 through 30 are to be used on the answer sheet.

Select the single answer that provides the best response to each question. Please be sure to use a No. 2 pencil and completely fill the box corresponding to your choice. If you change an answer, the previous mark must be completely erased.

A hand-held calculator may be used. However, any memory must be cleared of data and programs. Calculators are not to be shared.

Your score on this multiple choice test will be your number of correct answers. There is no penalty for guessing. It is to your advantage to answer every question.

The values of some possibly useful constants are given below:

mass of electron	$m_e = 9.1 \times 10^{-31} \text{ kg}$
mass of proton	$m_p = 1.7 \times 10^{-27} \text{ kg}$
electronic charge	$e = 1.6 \times 10^{-19} \text{ C}$
speed of light	$c = 3.0 \times 10^8 \text{ m/s}$
Coulomb's constant	$k = 9.0 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$
permittivity constant	$\epsilon_0 = 8.9 \times 10^{-12} \text{ C}^2/\text{N}\cdot\text{m}^2$
permeability constant	$\mu_0 = 4\pi \times 10^{-7} \text{ T}\cdot\text{m/A}$
gravitational constant	$G = 6.7 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$
mass of Earth	$M_E = 6.0 \times 10^{24} \text{ kg}$
radius of Earth	$R_E = 6.4 \times 10^6 \text{ m}$
gravitational field	$g = 9.8 \text{ N/kg}$
speed of sound (20 ⁰ C)	$v_s = 340 \text{ m/s}$

DO NOT OPEN THIS TEST UNTIL YOU ARE TOLD TO BEGIN

Copyright © 1999, American Association of Physics Teachers.

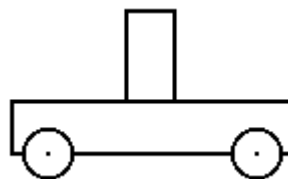
1. A truck driver travels three-fourths the distance of his run at one velocity (v) and then completes his run at one half his original velocity ($\frac{1}{2}v$). What was the trucker's average speed for the trip?

- [A] $0.85v$ [B] $0.80v$ [C] $0.75v$ [D] $0.70v$ [E] $0.65v$

2. Hercules and Ajax horizontally push in the same direction on a 1200 kg crate. Hercules pushes with a force of 500 newtons and Ajax pushes with a force of 300 newtons. If a frictional force provides 200 newtons of resistance, what is the acceleration of the crate?

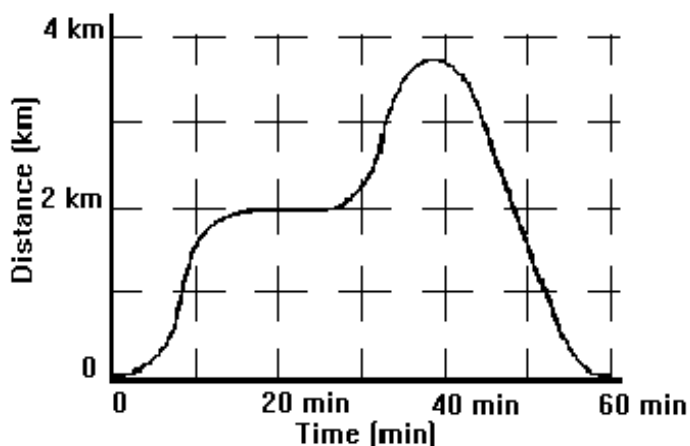
- [A] 1.3 m/s^2 [B] 1.0 m/s^2 [C] 0.87 m/s^2 [D] 0.75 m/s^2 [E] 0.5 m/s^2

3. A uniform 2 kg cylinder rests on a laboratory cart as shown. The coefficient of static friction between the cylinder and the cart is 0.5. If the cylinder is 4 cm in diameter and 10 cm in height, which of the following is closest to the minimum acceleration of the cart needed to cause the cylinder to tip over?



- [A] 2 m/s^2 [B] 4 m/s^2 [C] 5 m/s^2 [D] 6 m/s^2 [E] The cylinder would slide at all of these accelerations.

4. At right is a graph of the distance vs. time for car moving along a road. According the graph, at which of the following times would the automobile have been accelerating positively?



- [A] 0, 20, 38, & 60 min.
 [B] 5, 12, 29, & 35 min.
 [C] 5, 29, & 57 min.
 [D] 12, 35, & 41 min.
 [E] at all times from 0 to 60 min.

5. A ball which is thrown upward near the surface of the earth with a velocity of 50 m/s will come to rest about 5 seconds later. If the ball were thrown up with the same velocity on Planet X, after 5 seconds it would still be moving upwards at nearly 31 m/s. The magnitude of the gravitational field near the surface of Planet X is what fraction of the gravitational field near the surface of the earth?

- [A] 0.16 [B] 0.39 [C] 0.53 [D] 0.63 [E] 1.59

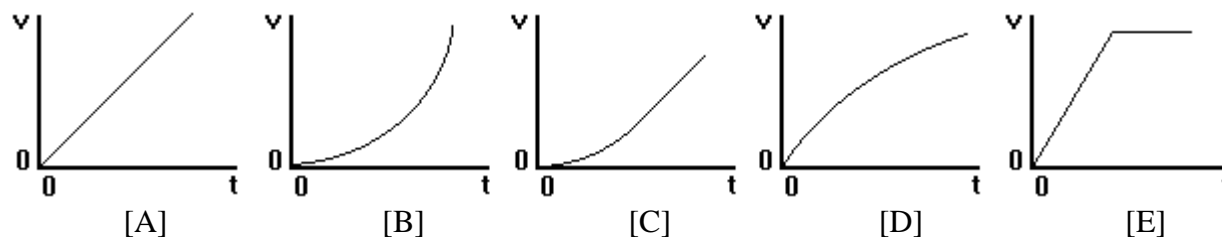
6. Two light plastic shopping bags of negligible mass are placed 2 meters apart. Each bag contains 15 oranges. If 10 oranges were moved from one bag to the other, the gravitational force between the two bags would

- [A] increase to $3/2$ the original value.
- [B] decrease to $2/5$ the original value.
- [C] increase to $5/3$ the original value.
- [D] decrease to $5/9$ the original value.
- [E] not change.

7. If a net force F applied to an object of mass m will produce an acceleration of a , what is the mass of a second object which accelerates at $5a$ when acted upon by a net force of $2F$?

- [A] $(2/5)m$
- [B] $2m$
- [C] $(5/2)m$
- [D] $5m$
- [E] $10m$

8. A large beach ball is dropped from the ceiling of a school gymnasium to the floor about 10 meters below. Which of the following graphs would best represent its velocity as a function of time?



9. A driver in a 1500 kg sports car wishes to pass a slow moving truck on a two lane road. What is the average power in watts required to accelerate the sports car from 20 m/s to 40 m/s in 3 seconds?

- [A] 10,000
- [B] 20,000
- [C] 100,000
- [D] 300,000
- [E] 400,000

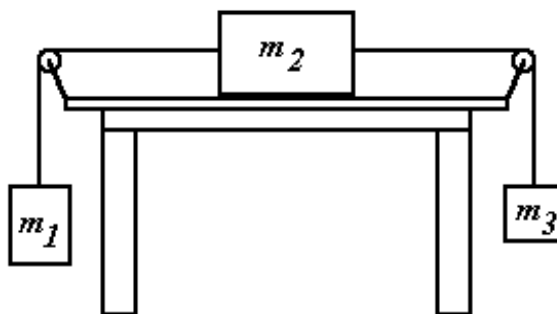
10. A 40 kg mass is attached to a horizontal spring with a constant of 500 N/m. If the mass rests on a frictionless horizontal surface, what is the total energy of this system when set into simple harmonic motion by an original displacement of 0.2 meters?

- [A] 10 J
- [B] 20 J
- [C] 50 J
- [D] 4000 J
- [E] 100,000 J

11. Two skaters on a frictionless pond push apart from one another. One skater has a mass M much greater than the mass m of the second skater. After some time the two skaters are a distance d apart. How far has the lighter skater moved from her original position?

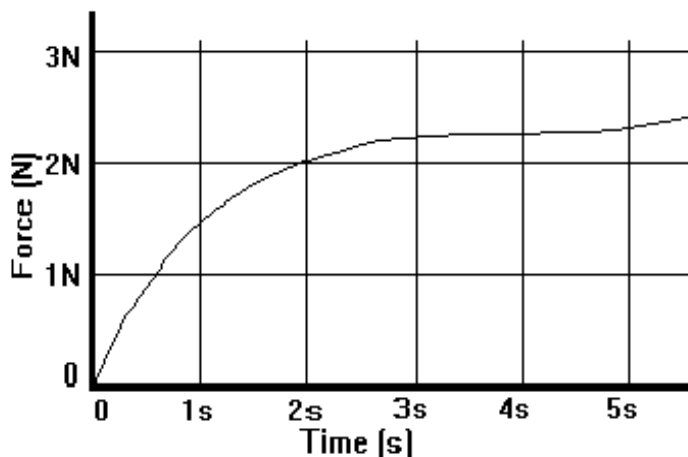
- [A] d [B] $d \left(\frac{M}{m} \right)$ [C] $d \left(\frac{m}{M} \right)$ [D] $d \left(\frac{m}{M+m} \right)$ [E] $d \left(\frac{M}{m+M} \right)$

12. Given the three masses as shown in the diagram, if the coefficient of kinetic friction between the large mass (m_2) and the table is μ , what would be the upward acceleration of the small mass (m_3)? The mass and friction of the cords and pulleys are small enough to produce a negligible effect on the system.



- [A] $\frac{m_1 g}{m_1 + m_2 + m_3}$ [B] $\frac{g(m_1 + m_2 - \mu m)}{m_1 + m_2 + m_3}$ [C] $\frac{g m m_1 + m_2 + m_3}{m_1 - m_2 - m_3}$
 [D] $\frac{g m m_1 - m_2 - m_3}{m_1 + m_2 + m_3}$ [E] $\frac{g(m_1 - m_2 - \mu m - m_3)}{m_1 + m_2 + m_3}$

13. An object with a mass of 2 kilograms is accelerated from rest. The graph at right shows the magnitude of the net force in newtons as a function of time in seconds. At $t = 4$ seconds the object's velocity would have been closest to which of the following:



- [A] 2.2 m/s
 [B] 3.5 m/s
 [C] 5.8 m/s
 [D] 7.0 m/s
 [E] 11.5 m/s

14. A thin ring of mass m and radius r rolls across the floor with a velocity v . Which of the following would be the best estimate of the ring's total kinetic energy as it rolls across the floor?

- [A] mv^2 [B] $\frac{1}{2}mv^2$ [C] $\frac{1}{4}mv^2$ [D] $\frac{1}{2}mv^2 + \frac{mv^2}{r}$ [E] $\frac{1}{2}mv^2 + m\frac{r^2}{t^2}$

15. A 4.0 kg mass is attached to one end of a rope 2 m long. If the mass is swung in a vertical circle from the free end of the rope, what is the tension in the rope when the mass is at its highest point if it is moving with a speed of 5 m/s?

- [A] 5.4 N [B] 10.8 N [C] 21.6 N [D] 50 N [E] 65.4 N

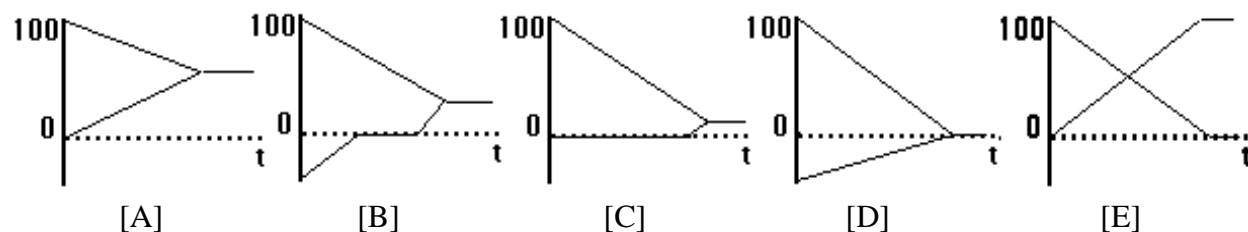
16. A mole of ideal gas at STP is heated in an insulated constant volume container until the average velocity of its molecules doubled. Its pressure would therefore increase by what factor?

- [A] 0.5 [B] 1 [C] 2 [D] 4 [E] 8

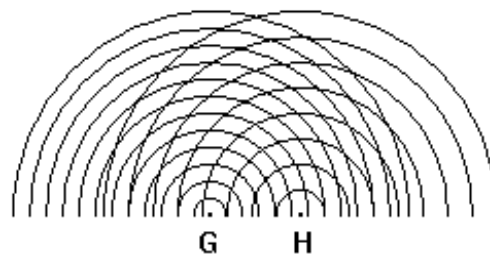
17. An ideal heat engine takes in heat energy at a high temperature and exhausts energy at a lower temperature. If the amount of energy exhausted at the low temperature is 3 times the amount of work done by the heat engine, what is its efficiency?

- [A] 0.25 [B] 0.33 [C] 0.67 [D] 0.9 [E] 1.33

18. If 100 g of ice at 0°C is mixed with 100 g of boiling water at 100°C , which of the following graphs would best represent the temperature vs time of the two components of the mixture?



19. Two wave sources, G and H, produce waves of different wavelengths as shown in the diagram. Lines shown in the diagram represent wave crests. Which of the following would be true of the resulting interference pattern?



- [A] The perpendicular bisector of GH would be an antinodal line.
 [B] The interference pattern will be a stable pattern but not symmetrical left to right.
 [C] The pattern of nodal and antinodal lines will sweep from left to right.
 [D] If G and H were moved farther apart, the fewer the number of nodal and antinodal lines.
 [E] There will not be an organized interference pattern because the sources are not producing the same frequency.

20. Given a wave produced by a simple harmonic oscillator whose displacement in meters is given by the equation: $y = .3 \sin(3\pi x + 24\pi t)$, what is the frequency of the wave in hertz?

- [A] 3 Hz [B] 7.2 Hz [C] 8 Hz [D] 12 Hz [E] 24 Hz

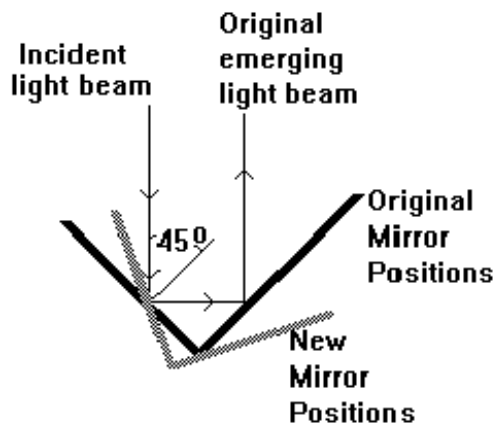
21. Which of the following wave properties cannot be demonstrated by all kinds of waves?

- [A] Polarization [B] Diffraction [C] Superposition [D] Refraction [E] Frequency

22. A source when at rest in a medium produces waves with a velocity v and a wavelength of λ . If the source is set in motion to the left with a velocity v_s , what would be the length of the wavelengths produced directly in front of the source?

- [A] $\lambda \left(1 - \frac{v_s}{v}\right)$ [B] $\lambda \left(1 + \frac{v_s}{v}\right)$ [C] $\lambda \left(1 + \frac{v}{v_s}\right)$ [D] $\frac{\lambda - v}{v - v_s}$ [E] $\frac{\lambda v}{v + v_s}$

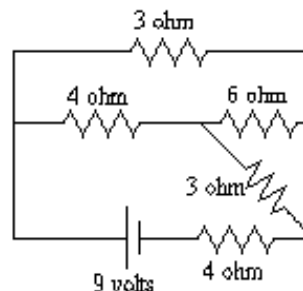
23. A beam of light strikes one mirror of a pair of right angle mirrors at an angle of incidence of 45° as shown in the diagram. If the right angle mirror assembly is rotated such that the angle of incidence is now 60° , what will happen to the angle of the beam that emerges from the right angle mirror assembly?



- [A] It will move through an angle of 15° with respect to the original emerging beam.
 [B] It will move through an angle of 30° with respect to the original emerging beam.
 [C] It will move through an angle of 45° with respect to the original emerging beam.
 [D] It will move through an angle of 60° with respect to the original emerging beam.
 [E] It will emerge parallel to the original emerging beam.

24. What would be the total current being supplied by the battery in the circuit shown?

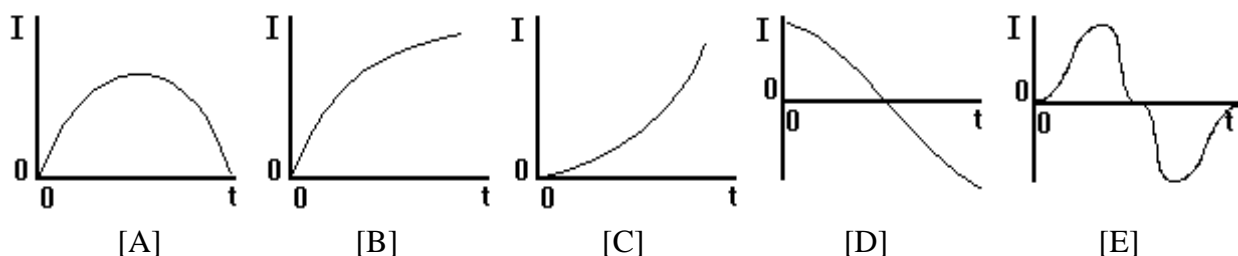
- [A] 3.0 amperes
 [B] 2.25 amperes
 [C] 2.0 amperes
 [D] 1.5 amperes
 [E] 1.0 amperes



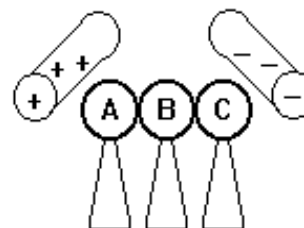
25. Consider a simple circuit containing a battery and three light bulbs. Bulb A is wired in parallel with bulb B and this combination is wired in series with bulb C. What would happen to the brightness of the other two bulbs if bulb A were to burn out?

- [A] only bulb B would get brighter.
- [B] both would get brighter.
- [C] bulb B would get brighter and bulb C would get dimmer.
- [D] bulb B would get dimmer and bulb C would get brighter.
- [E] There would be no change in the brightness of either bulb B or bulb C.

26. A coil of wire is moved vertically at a constant velocity through a horizontal magnetic field. Assume the plane of the coil is perpendicular to the magnetic field. Which of the following graphs would best represent the electric current induced in the coil if it started somewhat above the magnetic field and ended equally as far below the magnetic field ?

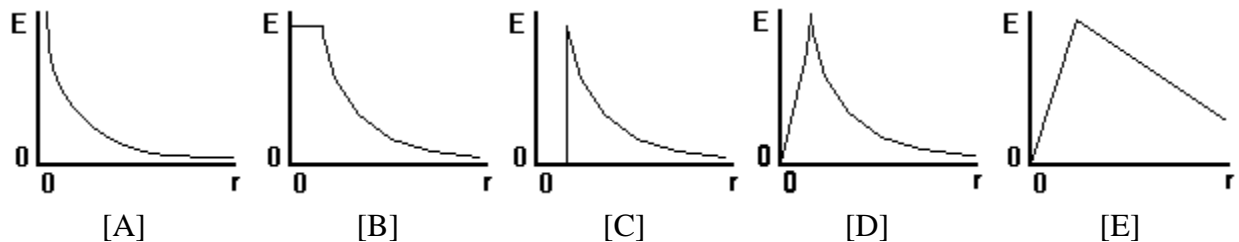


27. Three metal spheres A, B, and C are mounted on insulating stands. The spheres are touching one another, as shown in the diagram. A strong positively charged object is brought near sphere A and a strong negative charge is brought near sphere C. While the charged objects remain near spheres A and C, sphere B is removed by means of its insulating stand. After the charged objects are removed, sphere B is first touched to sphere A and then to sphere C. The resulting charge on B would be:



- [A] the same sign but $\frac{1}{2}$ the magnitude as originally on sphere A.
- [B] the opposite sign but $\frac{1}{2}$ the magnitude as originally on sphere A.
- [C] the opposite sign but $\frac{1}{4}$ the magnitude as originally on sphere A.
- [D] the same sign but $\frac{1}{2}$ the magnitude as originally on sphere C.
- [E] neutrally charged.

28. Which of the following graphs would best represent the electric field of a hollow Van de Graff sphere as a function of distance from its center when it is charged to a potential of 400,000 volts?

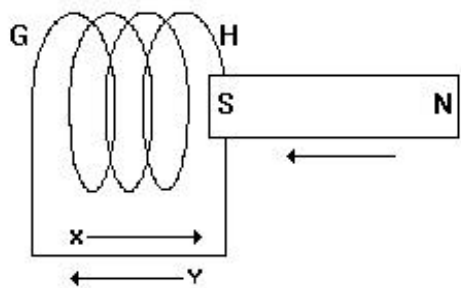


29. A mass spectrograph separates ions by weight using simple concepts from physics. Charged ions are given a specific kinetic energy by accelerating them through a potential difference. The ions then move through a perpendicular magnetic field where they are deflected into circular paths with differing radii. How would the radius of a singly ionized common helium atom (${}^4_2\text{He}^{1+}$) compare to the radius of a doubly ionized common oxygen atom (${}^{16}_8\text{O}^{2+}$) if they were accelerated through the same potential difference and were deflected by the same magnetic field?

- [A] The radius of the He ion path is 4 times the radius of the O ion path.
- [B] The radius of the O ion path is 2 times the radius of the He ion path.
- [C] The radius of the O ion path is 4 times the radius of the He ion path.
- [D] The radius of the O ion path is 8 times the radius of the O ion path.
- [E] The radius of the He ion path is equal to the radius of the O ion path.

30. A bar magnet is thrust into a coil of wire as indicated in the diagram. Which of the following statements concerning this experiment is correct?

- [A] The polarity of the coil at H is North, at G is South, and the induced current is indicated by arrow X.
- [B] The polarity of the coil at H is South, at G is North, and the induced current is indicated by arrow Y.
- [C] The polarity of the coil at H is North, at G is South, and the induced current is indicated by arrow Y.
- [D] The polarity of the coil at H is South, at G is North, and the induced current is indicated by arrow X.
- [E] There is no polarity to the coil and no current in the coil.



**1999 AAPT PHYSICS OLYMPIAD
MULTIPLE CHOICE SCREENING TEST
ANSWER KEY**

1. B	11. E	21. A
2. E	12. E	22. A
3. B	13. B	23. E
4. C	14. A	24. D
5. B	15. B	25. C
6. D	16. D	26. E
7. A	17. A	27. C
8. D	18. C	28. C
9. D	19. C	29. E
10. A	20. D	30. B