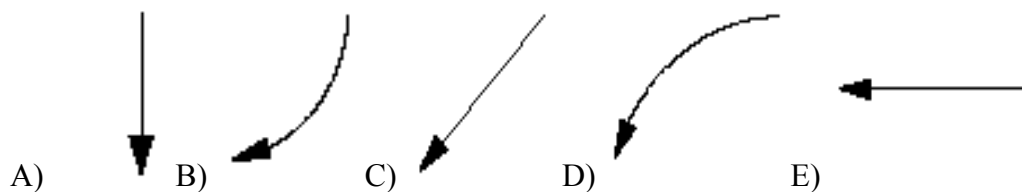


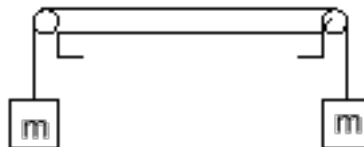
1. Given the acceleration vs. time graph for a car shown above, at what time will be moving with the greatest velocity?

- A) 0 seconds B) 2seconds C) 4 seconds D) 6 seconds E) 8 seconds

2. A car is moving at a constant velocity to the right along a straight level highway. Just as the car passes a cliff, a rock falls straight down in the cliff's reference system. Which of the accompanying curves best depicts the path the rock takes in the car's reference system?



3. Two identical masses  $m$  are connected to a massless string, which is hung over two frictionless pulleys as shown.



If everything is at rest, what is the tension in the cord?

- A) Less than  $mg$ ,  
 B) Exactly  $mg$ ,  
 C) More than  $mg$  but less than  $2mg$ ,  
 D) Exactly  $2mg$ ,  
 E) More than  $2mg$ .

4. A 60 kg farmer ropes a 300 kg ox. Both are initially at rest, 24 m apart on a frictionless level surface. When farmer ends up pulling the ox towards him, the ox will move

- A) 4m, B) 5m, C) 12m, D) 20m, E) 24m

5. A small bird with a mass of 0.5 kg takes off from the ground and flies with an upward velocity of 3 m/sec for 10 seconds. Which of the following is closest to the minimum power that must be developed by the bird?

- A) 60 watts    B) 15 watts    C) 9 watts    D) 6 watts    E) 1.5 watts

6. A solid cylinder weighing 200 N has a fixed axis and a string wound around it. The string is pulled with a force equal to the weight of the cylinder. The acceleration of the string is approximately

- A)  $10 \text{ m/s}^2$     B)  $20 \text{ m/s}^2$     C)  $30 \text{ m/s}^2$     D)  $40 \text{ m/s}^2$     E)  $50 \text{ m/s}^2$

7. A ball of mass  $m$  is tied to a string. The ball is then rotated in a vertical circle of radius  $R$  with the other end of the string fixed. Neglecting air resistance, the difference between the string's tension at the bottom of the circle and the top of the circle is

- A)  $mg$     B)  $2mg$     C)  $4mg$     D)  $6mg$     E)  $8mg$

8. Suppose you hold a ball in your hand. The Newton's third law companion force to the force of gravity on the ball is the force exerted by the

- A) Ball on the Earth  
B) Ball on the hand  
C) Hand on the ball  
D) Earth on the ball  
E) Earth on the hand.

9. A ball is tossed straight up, reaches a highest point, and falls back down. Air resistance is not negligible. Which of the following statements are true?

- I) The ball's speed is zero at the highest point.  
II) The ball's acceleration is zero at the highest point.  
III) The ball takes longer time to travel up to the highest point than to fall back down.

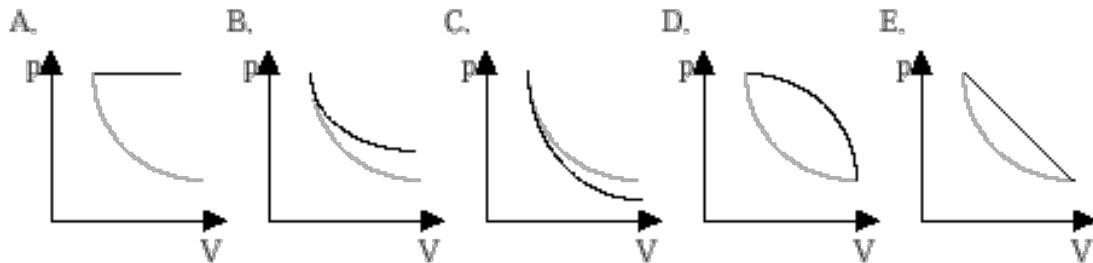
- A) I only  
B) II only  
C) I & II only  
D) I & III only  
E) I, II & III

10. Two iron spheres separated by some distance have a minute gravitational attraction  $F$ . If the spheres are moved to one half their original separation and allowed to rust so that the mass of each sphere increases 41% , what would be the resulting gravitational force?

- A)  $2F$     B)  $4F$     C)  $6F$     D)  $8F$     E)  $10F$

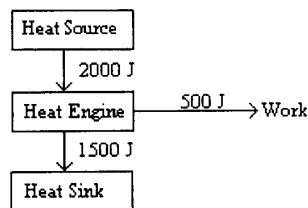
11. A block of ice with mass  $m$  falls into a lake. After impact, a mass of ice  $m/5$  melts. Both the block of ice and the lake have a temperature of  $0^\circ\text{C}$ . If  $L$  represents the heat of fusion, the minimum distance the ice fell is

- A)  $L/5g$       B)  $5L/g$       C)  $gL/5m$       D)  $mL/5g$       E)  $5gL/m$



12. On all the PV diagrams shown above the lighter curve represents an isothermal process, a process for which the temperature remains constant. Which dark curve best represents an adiabatic process where no heat enters or leaves the system?

- A)                  B)                  C)                  D)                  E)



13. For the diagram given above, what is the efficiency of the heat engine?

- A) 300%      B) 133%      C) 75%      D) 33%      E) 25%

14. If heat is added at constant volume, 6300 joules of heat are required to raise the temperature of an ideal gas by 150K. If instead, the heat is added at constant pressure, 8800 joules are needed for the same temperature change. When the temperature of the gas changes by 150K, the internal energy of the gas changes by

- A) 2500J      B) 6300J      C) 8800J      D) 11300J      E) 15100J

15. One object has twice the temperature of a second identical object. How does the rate  $R_1$  at which the first object radiates energy compare to the rate  $R_2$  at which the second object radiates energy?

- A)  $R_1 = R_2$       B)  $R_1 = 2R_2$       C)  $R_1 = 4R_2$       D)  $R_1 = 8R_2$       E)  $R_1 = 16R_2$

16. A pipe, which is open at both ends, resonates with fundamental frequency 300 Hz. If one end of the pipe is closed, it will resonate with a fundamental frequency of

- A) 75 Hz, B) 150 Hz, C) 300 Hz, D) 600 Hz, E) 1200 Hz.

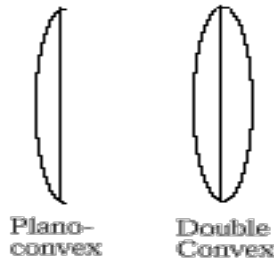
17. A wave is described by the equation  $y(x,t) = 0.05 \cdot \cos ( 10 \pi x + 8 \pi t )$  where  $x$  and  $y$  are in meters and  $t$  is in seconds. The  $+x$  direction is to the right. What is the velocity of the wave?

- A) 0.80 m/s to the left  
B) 1.25 m/s to the right  
C)  $0.12\pi$  m/s to the right  
D) 0.80 m/s to the right  
E) 1.25 m/s to the right

18. The length of the most effective transmitting antenna is equal to one-quarter the wavelength of the transmitted wave. If a radio station has an antenna 4.5 m long then what is the broadcast frequency of the radio station?

- A)  $1.5 \times 10^{-8}$  Hz B)  $6.0 \times 10^{-8}$  Hz C)  $1.7 \times 10^7$  Hz D)  $6.7 \times 10^7$  Hz E)  $3 \times 10^8$  Hz

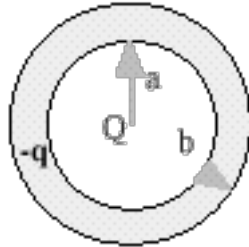
19. You are given two identical Plano-convex lens. When an object is placed 20 cm to the left of a single such lens, the image appears 40 cm to the right of the lens. Then you decide to form a double convex lens by placing the two Plano-convex lenses back-to-back.



If an object is placed 20 cm to the left of this new lens, the image is formed at a distance

- A) 6.7cm to the right of the lens.  
B) 10 cm to the right of the lens.  
C) 20 cm to the right of the lens.  
D) 80 cm to the right of the lens.  
E) 80 cm to the left of the lens.

The questions 20 and 21 refer to the system, shown in the accompanying diagram. A spherical shell of inner surface radius  $a$  and an outer surface radius  $b$  is made of conducting material. A point charge  $+Q$  is placed at the center of the spherical shell and a total charge  $-q$  is placed on the shell.



20. How is the charge  $-q$  distributed after it has reached equilibrium?

- A) Zero charge on the inner surface,  $-q$  charge on the outer surface.
- B)  $-Q$  charge on the inner surface,  $-q$  charge on the outer surface.
- C)  $-Q$  charge on the inner surface,  $-q+Q$  charge on the outer surface.
- D)  $+Q$  charge on the inner surface,  $-q -Q$  charge on the outer surface.
- E) The  $-q$  charge is spread uniformly between the inner and outer surface.

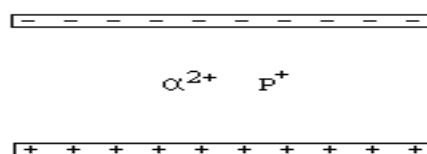
21. Assume that the electrostatic potential is zero at an infinite distance from the shell. What is the electrostatic potential at a distance  $R$  from the center of the shell where  $b > R > a$ ?

- A) 0            B)  $k Q/a$             C)  $k Q/R$             D)  $k (Q-q)/R$             E)  $k (Q-q)/b$

22. An alpha particle is accelerated to a velocity  $v$  in a particle accelerator by a potential difference of 1200 V. Which of the following potential differences would be needed to give the alpha particle twice the velocity?

- A) 7200V            B) 4800V            C) 4100V            D) 2400V            E) 1700V

23. An alpha particle and a proton are placed equal distance between two large charged plates as shown in the figure.



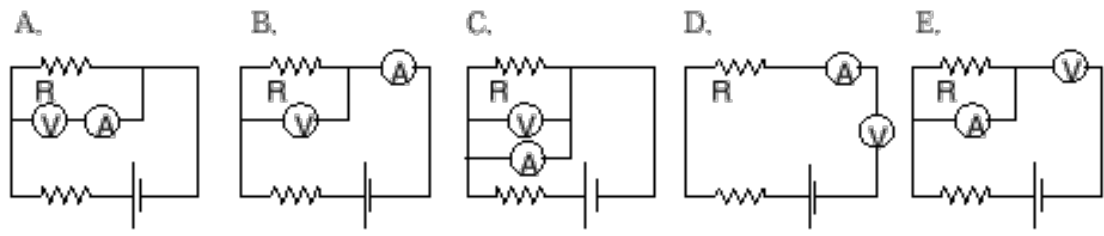
Which of the following would best describe the motion of the two particles if they were free to move?

- A) The alpha particle will travel upwards with the twice the velocity of the proton.
- B) Both particles will travel upwards with the same velocity.
- C) The alpha particle will accelerate upwards with twice the acceleration of the proton.
- D) Both particle will accelerate upwards with the same acceleration
- E) The alpha particle will accelerate upwards with half the acceleration of the proton.

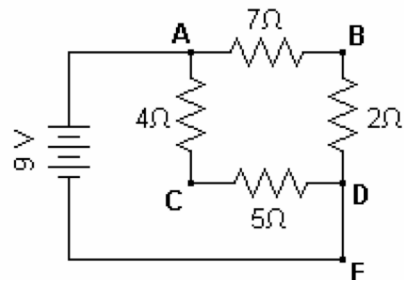
24. The longest wavelength photon in the visible Balmer series for the hydrogen atom is

- A) 0.66 nm    B) 6.56 nm    C) 65.6 nm    D) 656 nm    E) 6560 nm

25. Which of the following wiring diagrams could be used to experimentally determine R using Ohm's law? Assume an ideal voltmeter and an ideal ammeter.



A 9-volt battery is connected to four resistors to form a simple circuit as shown below.



26. What would be the current at point E in the circuit?

- A) 2amp    B) 4amp    C) 5amp    D) 7amp    E) 9amp

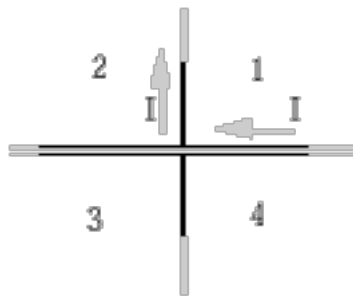
27. What would be the potential at point B with respect to point D?

- A) +2V    B) +4V    C) +5V    D) +7V    E) +9V

28. The most common isotope of Uranium,  $^{238}_{92}\text{U}$  radioactively into  $^{206}_{82}\text{Pb}$ , Lead through a series of alpha and beta particle emissions. How many of each particle must be emitted?

- A) 32 alphas and 10 betas
- B) 16 alphas and 16 betas
- C) 16 alphas and 8 betas
- D) 8 alphas and 6 betas
- E) 4 alphas and 16 betas

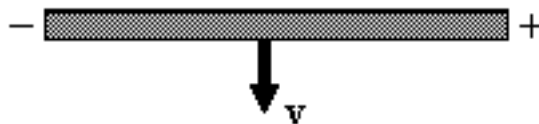
29. Identical currents flow in two perpendicular wires, as shown in the accompanying figure. The wires are very close but do not touch ( you can think of them being insulated).



The magnetic field can be zero

- A) At a point in region 1 only
- B) At a point in region 2 only
- C) At points in both regions 1 and 2.
- D) At points in both regions 1 and 4.
- E) At points in both regions 2 and 4.

30. A wire moves with a velocity  $v$  through a magnetic field and experiences an induced charge separation as shown in the figure



What is the direction of the magnetic field?

- A) Into the page.
- B) Out of the page
- C) Towards the bottom of the page
- D) Towards the right
- E) Towards the top of the page.