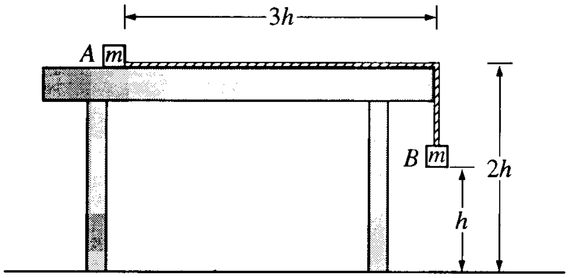
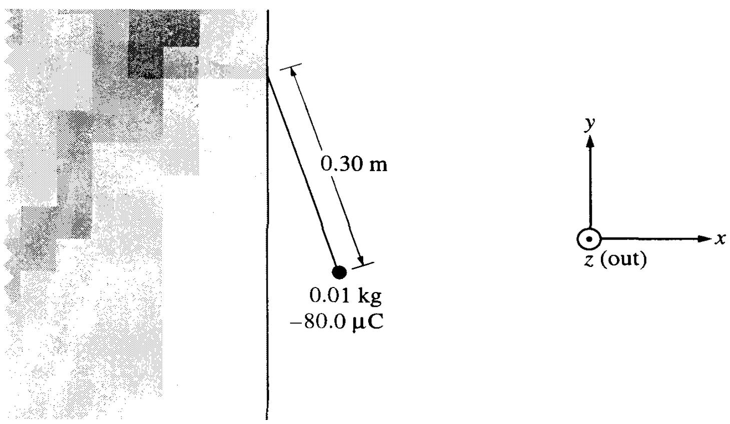
# AP® Physics B
# 1998 Free response Questions



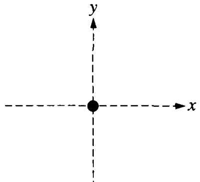

1998B1 (15 points) Two small blocks, each of mass m, are connected by a string of constant length 4h and negligible mass. Block A is placed on a smooth tabletop as shown above, and block B hangs over the edge of the table. The tabletop is a distance 2h above the floor. Block A is then released from rest at a distance h above the floor at time t = 0. Express all algebraic answers in terms of h, m, and g.

a. Determine the acceleration of block A as it descends.
b. Block B strikes the floor and does not bounce. Determine the time $t = t_1$ at which block B strikes the floor.
c. Describe the motion of block A from time t = 0 to the time when block B strikes the floor.
d. Describe the motion of block A from the time block B strikes the floor to the time block A leaves the table.
e. Determine the distance between the landing points of the two blocks.

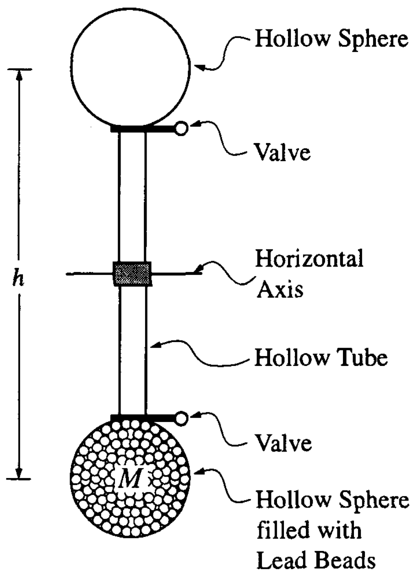



(15 points) 1998B2. A wall has a negative charge distribution producing a uniform horizontal electric field. A small plastic ball of mass 0.01 kg, carrying a charge of -80.0 μC is suspended by an uncharged, nonconducting thread 0.30 m long. The thread is attached to the wall and the ball hangs in equilibrium, as shown above, in the electric and gravitational fields. The electric force on the ball has a magnitude of 0.032 N.

a. On the diagram below, draw and label the forces acting on the ball.




b. Calculate the magnitude of the electric field at the ball's location due to the charged wall, and state its direction relative to the coordinate axes shown.
c. Determine the perpendicular distance from the wall to the center of the ball.
d. The string is now cut.
   i. Calculate the magnitude of the resulting acceleration of the ball, and state its direction relative to the coordinate axes shown.
   ii. Describe the resulting path of the ball.




1998B3 (10 points) Students are designing an experiment to demonstrate the conversion of mechanical energy into thermal energy. They have designed the apparatus shown in the figure above. Small lead beads of total mass M and specific heat c fill the lower hollow sphere. The valves between the spheres and the hollow tube can be opened or closed to control the flow of the lead beads. Initially both valves are open.

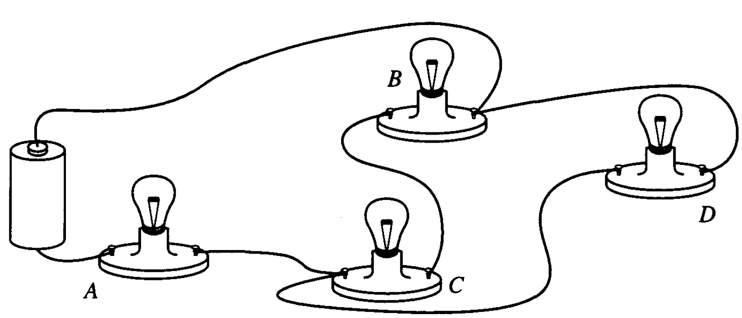
a. The lower valve is closed and a student turns the apparatus 180° about a horizontal axis, so that the filled sphere is now on top. This elevates the center of mass of the lead beads by a vertical distance h. What minimum amount of work must the student do to accomplish this?

b. The valve is now opened and the lead beads tumble down the hollow tube into the other hollow sphere. If all of the gravitational potential energy is converted into thermal energy in the lead beads, what is the temperature increase of the lead?

c. The values of M, h, and c for the students' apparatus are M = 3.0 kg, h = 2.00 m, and c = 128 J/(kg · K). The students measure the initial temperature of the lead beads and then conduct 100 repetitions of the "elevate-and-drain" process. Again, assume that all of the gravitational potential energy is converted into thermal energy in the lead beads. Calculate the theoretical cumulative temperature increase after the 100 repetitions.

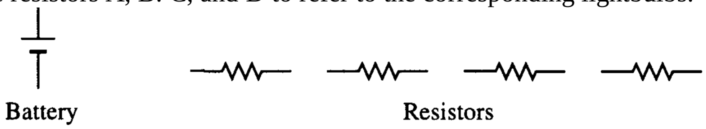
d. Suppose that the experiment were conducted using smaller reservoirs, so that M was one-tenth as large (but h was unchanged). Would your answers to parts (b) and (c) be changed? If so, in what way, and why? If not, why not?

e. When the experiment is actually done, the temperature increase is less than calculated in part (c). Identify a physical effect that might account for this discrepancy and explain why it lowers the temperature.



1998B4 (10 points) In the circuit shown above, A, B. C, and D are identical lightbulbs. Assume that the battery maintains a constant potential difference between its terminals (i.e., the internal resistance of the battery is assumed to be negligible) and the resistance of each lightbulb remains constant.

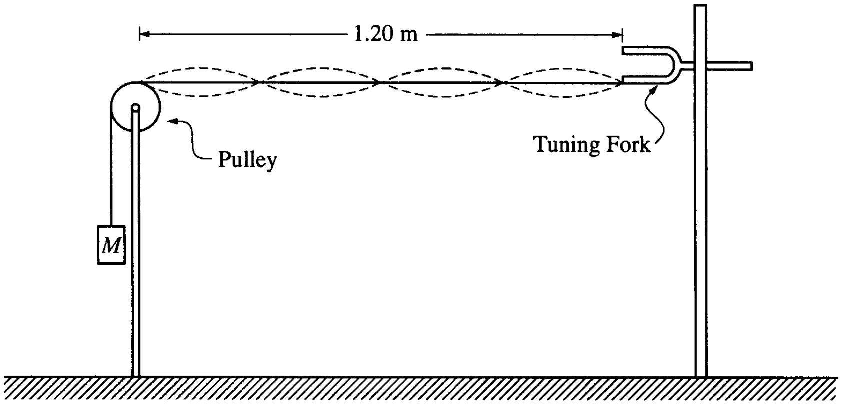
a. Draw a diagram of the circuit in the box below, using the following symbols to represent the components in your diagram. Label the resistors A, B. C, and D to refer to the corresponding lightbulbs.




Draw your diagram in this box only.

b. List the bulbs in order of their brightnesses, from brightest to least bright. If any two or more bulbs have the same brightness, state which ones. Justify your answer.

c. Bulb D is then removed from its socket.
   i. Describe the change in the brightness, if any, of bulb A when bulb D is removed from its socket. Justify your answer.
   ii. Describe the change in the brightness, if any, of bulb B when bulb D is removed from its socket. Justify your answer.



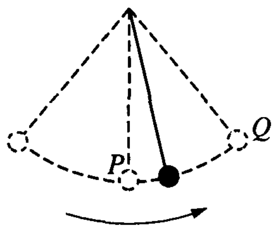

1998B5 (10 points) To demonstrate standing waves, one end of a string is attached to a tuning fork with frequency 120 Hz. The other end of the string passes over a pulley and is connected to a suspended mass M as shown in the figure above. The value of M is such that the standing wave pattern has four "loops." The length of the string from the tuning fork to the point where the string touches the top of the pulley is 1.20 m. The linear density of the string is $1.0 \times 10^{-4}$ kg/m, and remains constant throughout the experiment.

a. Determine the wavelength of the standing wave.

b. Determine the speed of transverse waves along the string.

c. The speed of waves along the string increases with increasing tension in the string. Indicate whether the value of M should be increased or decreased in order to double the number of loops in the standing wave pattern. Justify your answer.

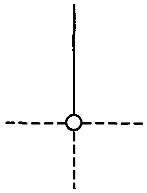
d. If a point on the string at an antinode moves a total vertical distance of 4 cm during one complete cycle, what is the amplitude of the standing wave?

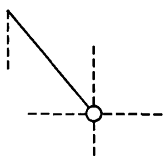



1998B6 (10 points) A heavy ball swings at the end of a string as shown above, with negligible air resistance. Point P is the lowest point reached by the ball in its motion, and point Q is one of the two highest points.

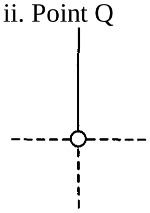
a. On the following diagrams draw and label vectors that could represent the velocity and acceleration of the ball at points P and Q. If a vector is zero, explicitly state this fact. The dashed lines indicate horizontal and vertical directions.

i. Point P



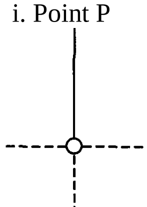


ii. Point Q

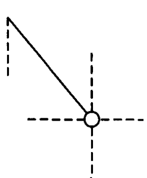


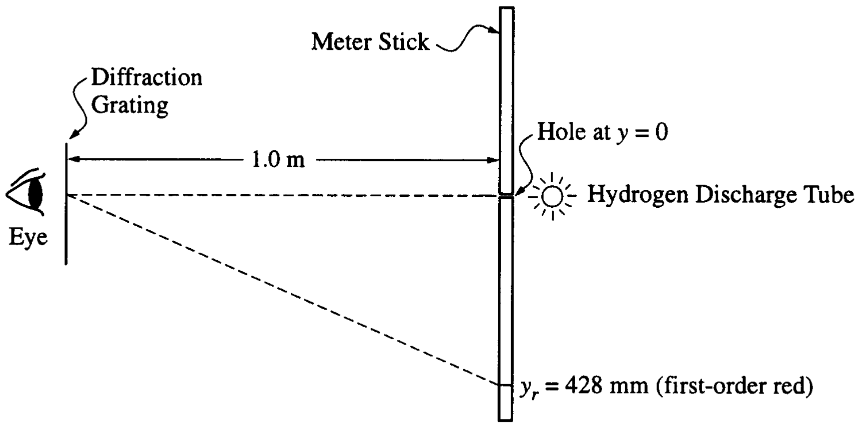
b. After several swings, the string breaks. The mass of the string and air resistance are negligible. On the following diagrams, sketch the path of the ball if the break occurs when the ball is at point P or point Q. In each case, briefly describe the motion of the ball after the break.

i. Point P



ii. Point Q






<u>Note:</u> **Figure is drawn to scale.**

1998B7 (10 points) A transmission diffraction grating with 600 lines/mm is used to study the line spectrum of the light produced by a hydrogen discharge tube with the setup shown above. The grating is 1.0 m from the source (a hole at the center of the meter stick). An observer sees the first-order red line at a distance $y_r$ = 428 mm from the hole.

a. Calculate the wavelength of the red line in the hydrogen spectrum.

b. According to the Bohr model, the energy levels of the hydrogen atom are given by $E_n = -13.6\ eV/n^2$, where n is an integer labeling the levels. The red line is a transition to a final level with n = 2. Use the Bohr model to determine the value of n for the initial level of the transition.

c. Qualitatively describe how the location of the first-order red line would change if a diffraction grating with 800 lines/mm were used instead of one with 600 lines/mm.

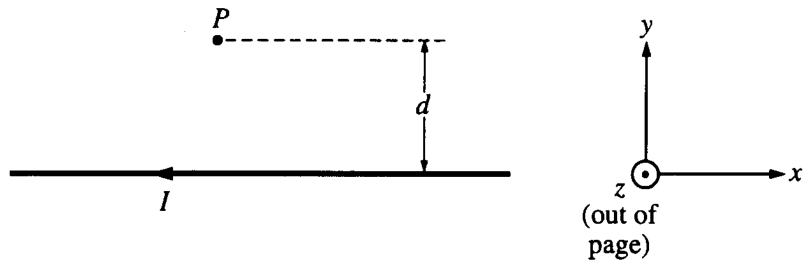



Figure 1

1998B8 (10 points) The long, straight wire shown in Figure 1 above is in the plane of the page and carries a current I. Point A is also in the plane of the page and is a perpendicular distance d from the wire. Gravitational effects are negligible.

a. With reference to the coordinate system in Figure 1, what is the direction of the magnetic field at point A due to the current in the wire?

A particle of mass m and positive charge a is initially moving parallel to the wire with a speed do when it is at point P. as shown in Figure 2 below.

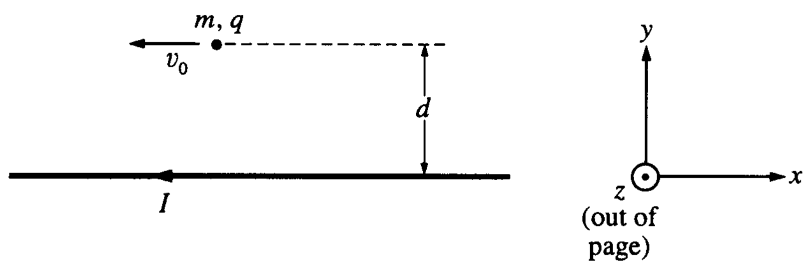



Figure 2

b. With reference to the coordinate system in Figure 2, what is the direction of the magnetic force acting on the particle at point A ?
c. Determine the magnitude of the magnetic force acting on the particle at point A in terms of the given quantities and fundamental constants.
d. An electric field is applied that causes the net force on the particle to be zero at point P.
    i. With reference to the coordinate system in Figure 2, what is the direction of the electric field at point A that could accomplish this?
    ii. Determine the magnitude of the electric field in terms of the given quantities and fundamental constants.