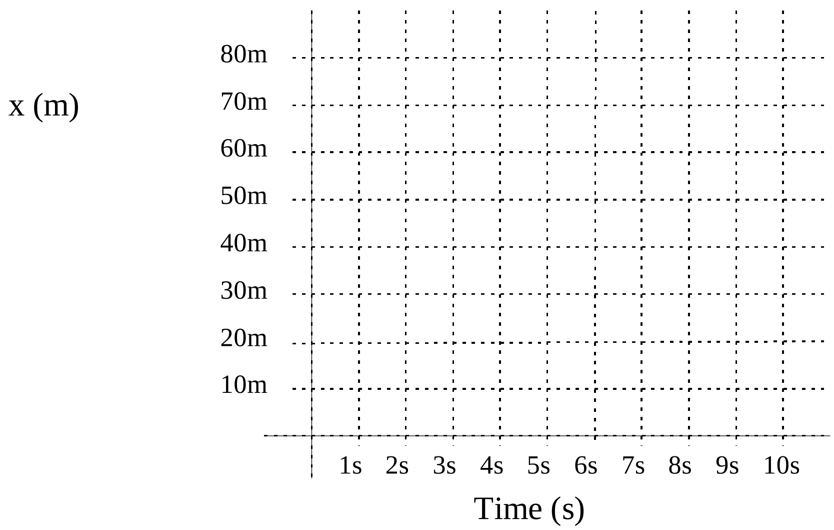
Two cars starting from rest at the same position are facing east on a straight road. The 1st car starts moving at $t = 0$ seconds and accelerates at $5\ m/s^2$ for 2 seconds then travels at a constant speed. The 2nd car starts moving 3 seconds after the 1st car started and accelerates at $20\ m/s^2$ for 1 second and then travels at constant speed.

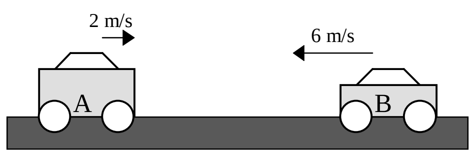
a) In the space below sketch a position vs. time graph for each car, labeling each car's curve. Explain how you determined the shape of the graph.



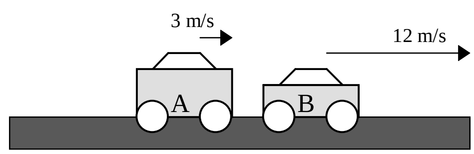
b) State whether the second car catches up with the first car in the first 10 seconds. If the second car does catch up with the first car, state when and where the 2nd car catches up, and explain how you know. If the second car does not catch up explain how you know.

c) State whether or not the two cars are ever at the same speed at the same time after $t = 0$ seconds. Explain how you could tell from the graph.

Two carts move toward each other on a tabletop. Initially (at t=0), cart A has a velocity of 2 m/s and an acceleration of 2 m/s^2 and cart B has a constant velocity of –6 m/s as shown below. The two cars hit at t=2.5 s. (Assume that the carts are in contact for only an instant.) Right after the two carts hit, cart A and cart B are seen to be going at constant velocities of 3 m/s and 12 m/s, respectively.



t=0 s (before collision)



(after collision)

a) Draw **and** calculate the magnitudes of the velocity and acceleration vectors for **cart A** at the times indicated (be sure to label the velocity and acceleration vectors).

i. t = 1 s

	vector	magnitude
velocity		
acceleration		

ii. t = 2 s

	vector	magnitude
velocity		
acceleration		

iii. t = 3 s

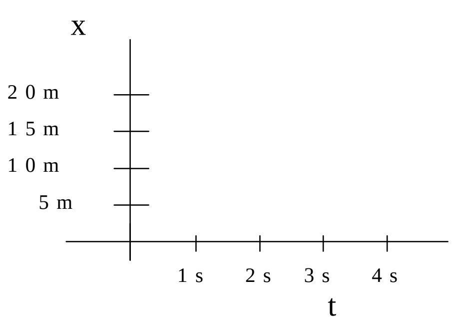
	vector	magnitude
velocity		
acceleration		

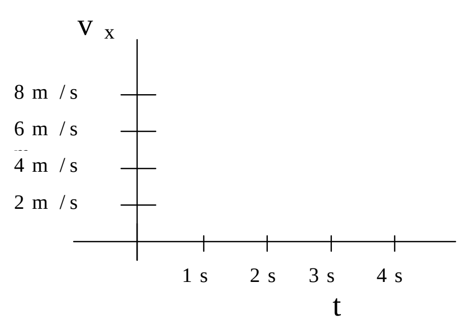
iv. t = 4 s

	vector	magnitude
velocity		
acceleration		

b) Find the average acceleration for **cart B** between t=2 s and t=3 s. Show all work.

c) Sketch the following graphs for **cart A** from t=0 s to t=4 s





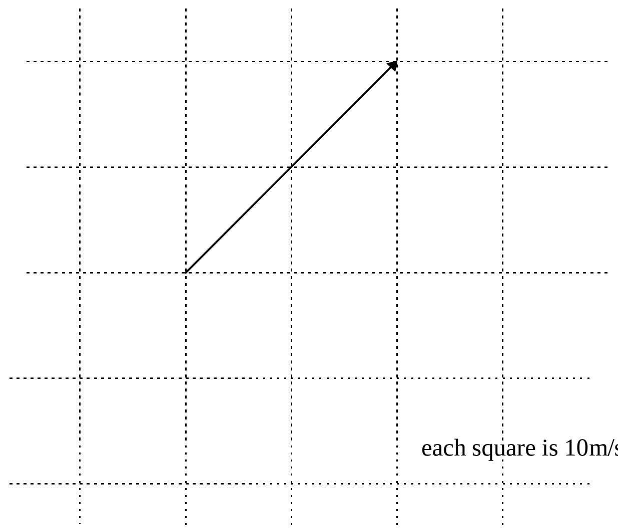
A cannon ball is fired from a cannon at an angle of 45° with respect to the horizontal. The ball has an initial velocity of 28 m/s. (Ignore air resistance.)

a) What is $\Delta \bar{v}$ within the following time intervals. Be sure to indicate magnitude and direction and explain your answer.

   i. t=0 s and t=1 s

   ii. t=1 s and t=2 s

b) Draw the velocities vectors for t=1 s, t=2 s, t=3 s, and t=4 s on the grid. The velocity vector at t=0 s is shown. Explain how you determined the vectors.

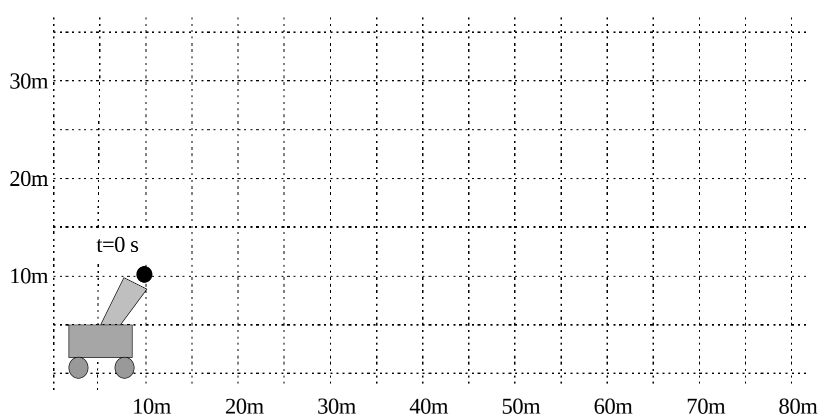


c) Draw and label the *average* velocity vectors on the grid above with dotted lines, for the following time intervals. Explain how you determined your answer.

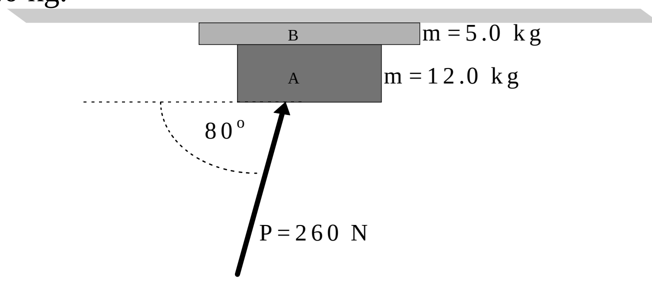
   i. t=0s to t=1 s

   ii. t=0s to t=2 s

d) Sketch a strobe photograph of the ball showing its location at 1 second time intervals. Note that the position at t=0 s has already been done. Show your work.



A pole is used to hold two blocks at rest on a ceiling as shown below. The pole exerts a force of 260 N at an angle of 80° on block A. The mass of block A is 12.0 kg and the mass of block B is 5.0 kg.



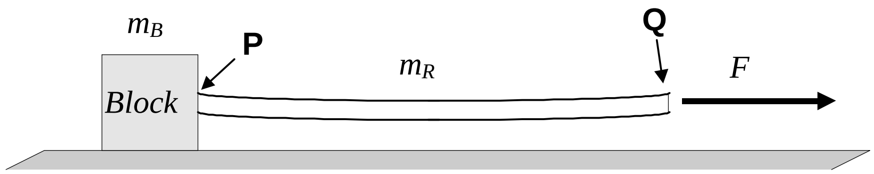
a) Sketch the free-body diagrams of block A and block B. For each force on your diagrams, state the type of force (e.g., gravitational, frictional, etc.)

b) Are there any forces in your free-body diagrams that are equal in magnitude to each other? If so, which ones are they and how do you know they are equal?

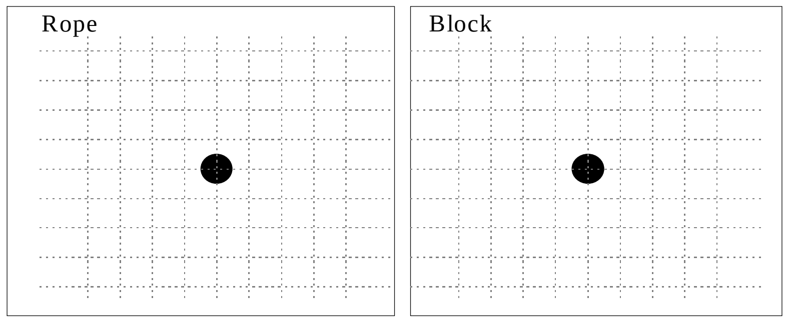
c) Calculate the normal force exerted by block B on block A. Show your work.

d) Rank all the forces on your free body diagram for block A from largest to smallest. Explain your reasoning.

Suppose a hand applies a force F to the end of a rope attached to a block so that the entire system has an acceleration of a toward the right. The rope has a mass m_R, and the block has a mass m_B. Assume that the friction between the block and the surface is negligible.



a) In the space at right sketch a free-body diagram for the rope and the block. Be sure the relative magnitudes of the forces are consistent with the physical situation. For each force in your free body diagrams indicate the object exerting the force and the object upon which the force is exerted.

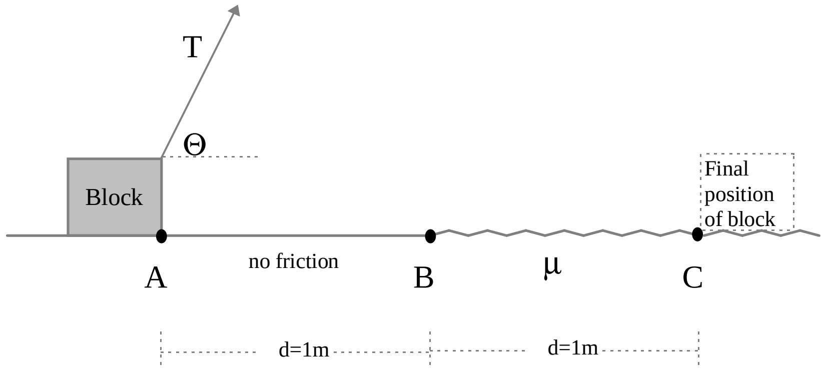


b) Compare the x-component of the tension at point **P** to the x-component of the tension at point **Q**. Explain your reasoning.

c) Calculate the tension in the rope at points **P** and **Q** if m_B=5kg, m_R=0.2kg, and the system accelerates at 2m/s^2. Assume that the rope is nearly parallel with the surface.

d) If the rope is replaced with a massless string, compare the tension at points **P** and **Q** to each other. Explain your reasoning.

A block is pulled from point A to point C by a tension force, T, as shown at right. The block starts off at rest at point A and speeds up to point B. The block then slows down finally stopping at point C (as shown). The magnitude and direction of the tension are constant throughout the motion. Note that the block is first pulled across a surface with no friction and is then pulled an equal distance across a surface with friction.



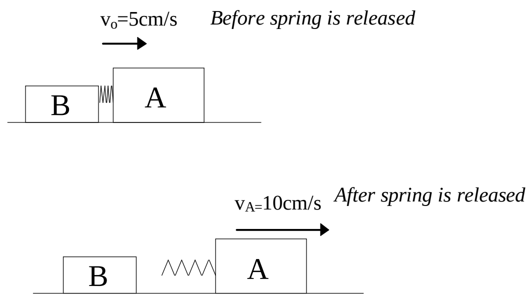
a) Draw a free-body diagram at right for the block when it's between B and C.

b) Is the magnitude of the net force acting on the block from A to B greater than, less than, or equal to the magnitude of the net force acting on the block from B to C? Explain your reasoning.

c) Calculate the coefficient of kinetic friction between the surface and the block between B and C if $\Theta=60^o$, $m_{block}=1.5kg$, and T=5N.

d) Calculate the work done by friction to move the block from A to C. Show all work.

Two carts are moving together, with a velocity of 5 cm/s $\hat{i}$, on a frictionless surface as shown at right. Cart A has a spring attached to it and the spring is in a locked position. At a time t_o the locked spring attached to cart A is released and the spring expands until it is no longer in contact with cart B. Consider cart A and the spring as system A, cart B as system B, and all three as system C. System A has a mass of 5 g, system B has a mass of 3 g, and the final velocity of system A is 10 cm/s $\hat{i}$



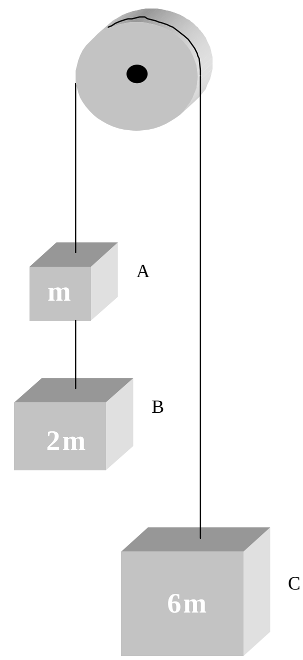
a) Compare the magnitude and direction of the force that each system exerts on the other as the spring expands. Explain how you arrived at your answer.

b) Compare the magnitude and direction of the impulse exerted on system A by system B to the impulse exerted on system B by system A. Explain how you arrived at your answer.

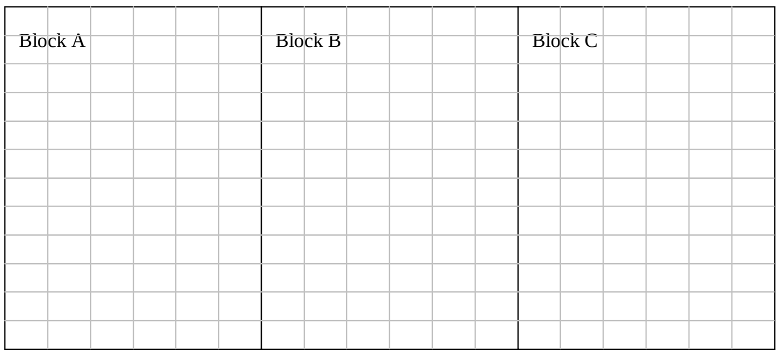
c) Find the final velocity of system B. Show all work.

d) Find the ΔKE of system C. Show all work.

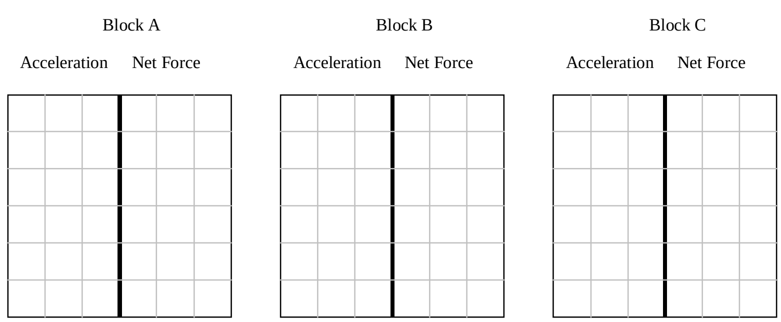
Three blocks are connected by a massless string, which goes over a massless pulley as shown at right. The mass of each block is given in the diagram.



a. Draw a free-body diagram for each block in the space provided. Label each force as you were instructed in tutorial.



b. For each block draw a vector representing the **net force** and the acceleration of each block. If any of the quantities are zero state that explicitly. Make your vectors for the three blocks consistent with each other.

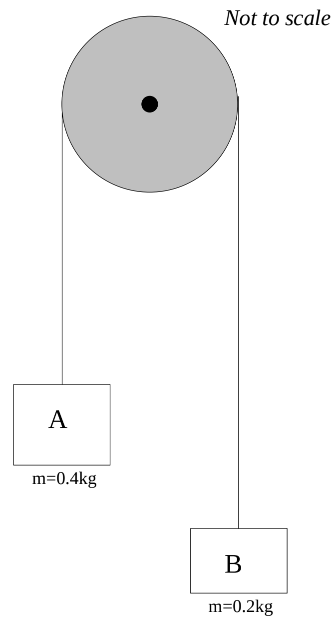


c. Rank the magnitudes of all the forces in your free-body diagrams. Explain your reasoning.

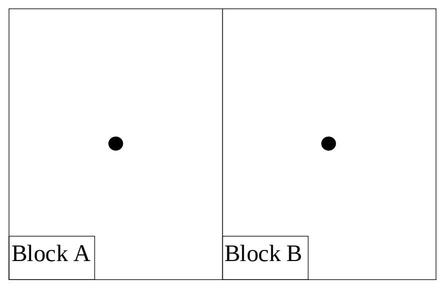
d. Calculate the acceleration of the large block. Show all work and explain your reasoning.

e. Rank the magnitudes of the net work done on the each block after they move a distance *d*. Assume they have not yet hit the pulley.

In the figure at the right is shown an Atwood's machine with two unequal masses attached by a massless string which does not slip. The pulley has a mass of 0.4kg, a radius of 0.2m, and a moment of inertia of 8×10^{-3} kg·m^2 about its center of mass. The masses are released from rest at t=0s.

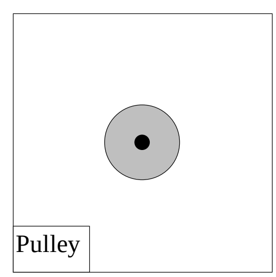


a) Draw a free body diagram for block A and block B after t = 0s. Make sure to label all the forces.



b) Rank the magnitudes of all the forces in your free body diagrams for the blocks. Explain your reasoning.

c) Draw a free body diagram for the pulley in the space provided.



d) What force(s) acting on the pulley cause it to rotate about its center of mass? Explain.

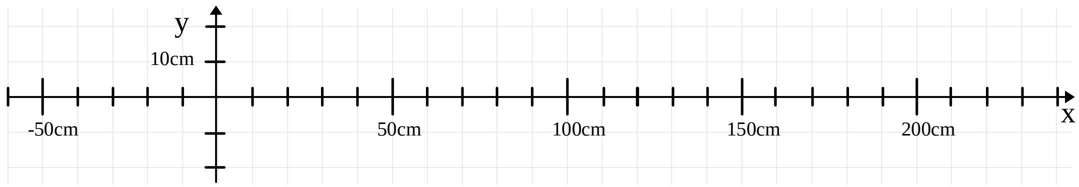
e) Calculate the acceleration of block B. Show all work.

f) What is the angular speed of the pulley after 5s. Show all work.

Consider a pulse traveling *to the right* with a speed of 600 cm/sec. The equation describing the displacement of the spring from equilibrium at time t = 0 sec is

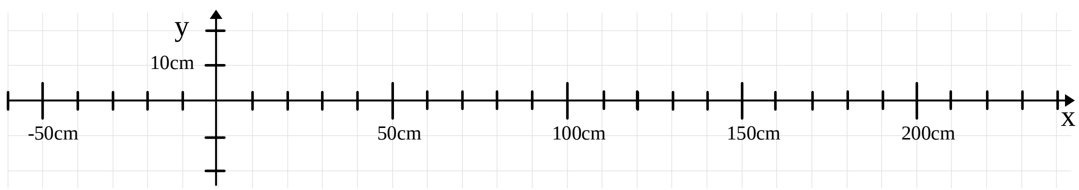
$y_1(x) = A_1 e^{-\left(\frac{x}{b_1}\right)^2}$, where A_1 = 20 cm and b_1 = 20 cm.

a) Sketch the shape of the spring at time t = 0 sec in the graph below. Use the indicated scale.



b) Write an equation that describes the displacement of any piece of the spring at any time for this pulse. Explain how you arrived at this answer.

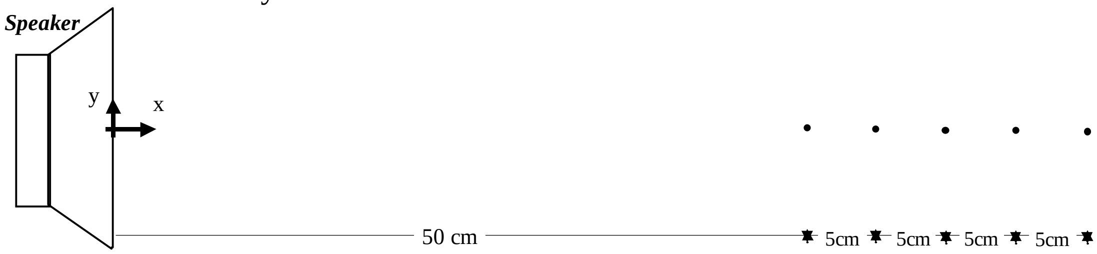
c) Now suppose a second pulse moving *to the left* is also present on the spring. At t = 0.1 sec the equation describing this 2^{nd} pulse is $y_2(x) = A_2 e^{-\left(\frac{x-200cm}{b_2}\right)^2}$ where A_2 = 10 cm and b_2 = 10 cm. Sketch the shape of the spring at time t = 0.1 sec in the graph below, labeling the pulse going to the right "1" and the pulse going to the left "2".



d) At what time and position do the maxima of the two pulses meet? Show your work.

e) Write an equation that describes the shape of the spring when the maxima meet. Show your work.

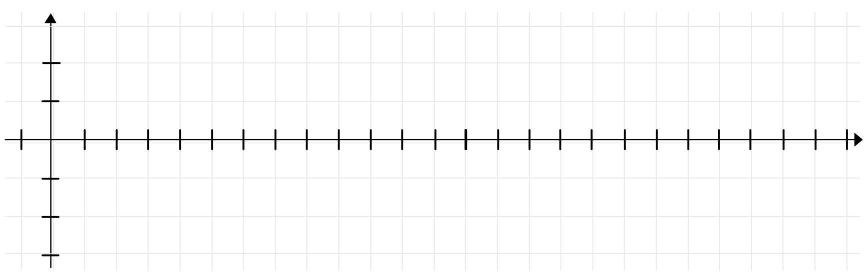
Five dust particles are placed in a row 5 cm apart beginning 50 cm from a loudspeaker (see figure). The speaker plays a note with a frequency of 1700 Hz. The speed of sound is 340 m/s. The maximum displacement of the first dust particle is s_{max} = 3 mm. Assume that the intensity of the sound wave is the same for all dust particles. In the indicated coordinate system, the origin is at the center of the loudspeaker. A clock is started at an arbitrary time.



a) At time t = 0 sec, the first dust particle is at equilibrium and moving away from the loudspeaker. Find t_0, the amount of time that elapses until the second dust particle is at its equilibrium position. Explain.

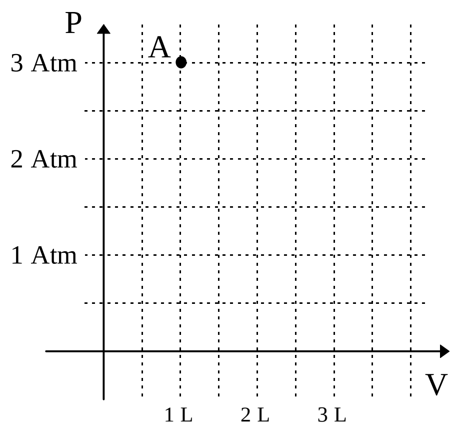
b) What is the displacement from equilibrium of the first dust particle at time t_0? Explain how you arrived at your answer.

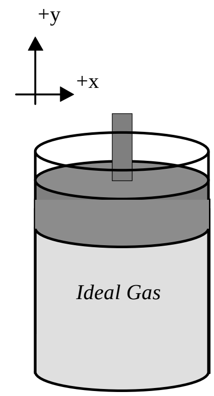
c) In the graph below, sketch a graph of s vs. x at time t_0. Define each axis clearly.



d) Find s(x,t) for x = 65 cm and t = 2.941176 x 10^{-4} sec. Show all work.

An ideal gas in a container with a piston starts at a pressure of 3 Atm and a volume of 1 L. The gas first goes through an isothermal process ending up with a pressure of 1 Atm and a volume of 3 L. The gas then undergoes a process at constant volume ending up with a final pressure of 3 Atm. (R=0.0821 L•Atm/mole•K)





a) Sketch the isothermal process on the PV diagram and label the resulting state "B."

b) Sketch the constant volume process on the PV diagram and label the final state "C."

c) What is the direction of the force exerted on the piston by the gas in the container in the process A⇒B? Is the work done by the gas positive, negative, or zero? Explain.

d) What is the direction of the force exerted on the piston by the gas in the container in the process B⇒C? Is the work done by the gas positive, negative, or zero? Explain.

e) Calculate the work done by the gas in the process A⇒B⇒C. Show all work.

The metal balls placed 10 cm apart each have mass of 1 g and a charge of 2.0×10^{-5} C (see diagram). Show all work for all questions.

a) Assume that the balls can be treated as point charges.

What is the electrical force exerted by the first ball on the second?

What is the electrical force exerted by the second ball on the first?

b) Compare the gravitational force exerted by each sphere on the other to the electrical force exerted by each sphere on the other. ($G = 6.7 \times 10^{-11}$ m^3/s^2kg)

c) How do the following changes affect the force exerted by each ball on the other?

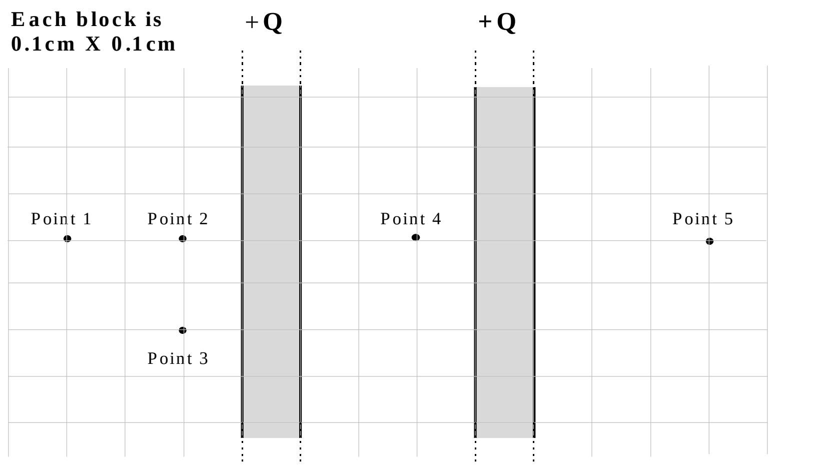
The distance between the balls is decreased by a factor of 2, to 5.0 cm.

The charge on the second ball is decreased by a factor of 2, to 1.0×10^{-5} C.

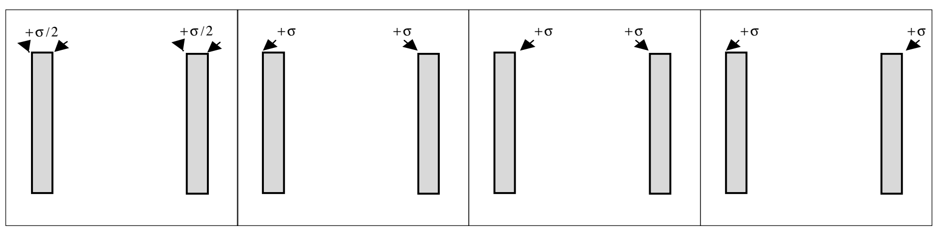
d) Suppose the balls cannot be treated as point charges. In this case, would you say that the force you calculated in part A is correct? If so, explain why it is correct. If not, explain why not and tell whether the force between the two balls would be greater than or smaller than your calculated value. (As part of your explanation, include a sketch that shows the distribution of charge on the two balls.)

Under what circumstances will the calculation you performed in part a) for the force between the two balls be *nearly* correct? Explain.

Consider two very large conducting plates a distance D apart. Both plates have a charge of +Q on them. See figure at right.



a) Which diagram below shows the correct charge distribution on the plates? Explain your reasoning.



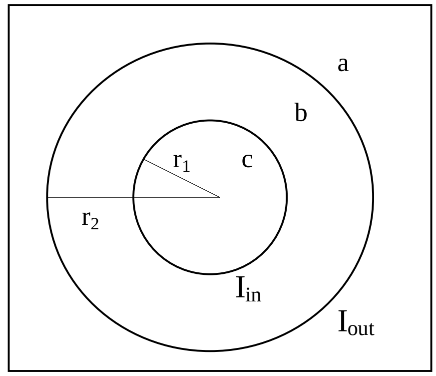
(a) (b) (c) (d)

b) Draw vectors on the diagram above representing the electric field at points 1, 2, 3, 4, and 5. If the field is zero at any point indicate that explicitly.

c) A small charge q, initially at rest at point 1, is moved by a hand so that it comes to rest at point 3. Write an equation for the work done on the charge.

d) If the charge density, σ, is 2 X 10^{-9} C/m^2, determine the potential difference between points 1 and 5. Show all work.

Consider a coaxial cable, as shown in a head-on view in the figure to the right. A coaxial cable consists of two very thin-walled concentric cylindrical wires with currents traveling in opposite directions. In this problem, the inner cylindrical wire with radius r_1 has a current, I, traveling *into* of the page, and the outer cylindrical wire with radius r_2 has a current, I, traveling *out* of the page. Labels *a*, *b*, and *c* indicate three regions in space.



a) Draw a path in region *b* such that the value of $\frac{1}{\mu_0}\oint \bar{B} \bullet d\bar{l}$ equals I. Which direction is your path? Explain how you arrived at your answer.

   Is this the only such path you could have drawn? Explain.

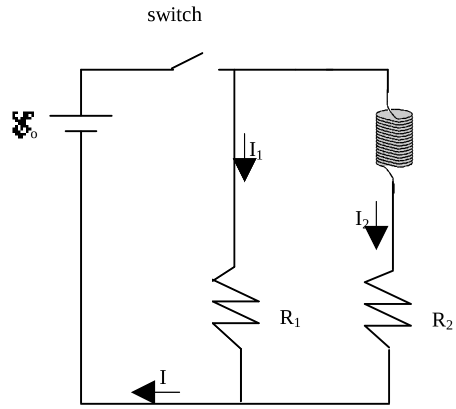
b) Find the magnetic field as a function of r and I in each of the three regions of space. Show all work.

c) Consider that the current on the inside wire equals zero, while the magnitude of the current on the outside is still I. How, if at all, does the magnetic field in each of the three regions differ from the values you found in question b? Explain how you arrived at your answer.

d) Consider that the current on the inside wire has a magnitude, I, while the current on the outside wire equals zero. How, if at all, does the magnetic field in each of the three regions differ from the values you found in question b? Explain how you arrived at your answer.

e) Consider that a current I flows through both coaxial wires (as indicated on the figure above). The value of r_1 is 1 cm and the value of r_2 is 4 cm. The value of I is 4 amps. Find the value of $|\bar{B}|$ a distance 3 cm from the axis of the wires.

Consider the circuit shown at right. Assume that the resistance across the solenoid and the wires is zero and that the battery is ideal.



A. Just after the switch has been closed, calculate the following. In each case explain how you determined your answer.

i. the current I_1 through the resistance R_1.

ii. the current I_2 through the resistance R_2.

iii. the total current I through the battery.

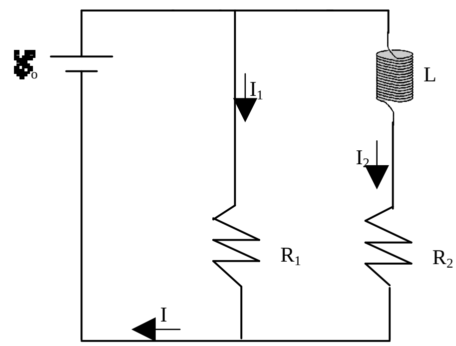
iv. the potential difference across R_2.

v. the potential difference across L.

vi. dI_2/dt

(continued on next page)

B. After the switch has been closed for a long time, calculate the following. In each case explain how you determined your answer. The figure from page 1 has been reproduced at right.



i. the current I_1 through the resistance R_1.

ii. the current I_2 through the resistance R_2.

iii. the total current I through the battery.

iv. the potential difference across R_2.

v. the potential difference across L.

vi. dI_2/dt