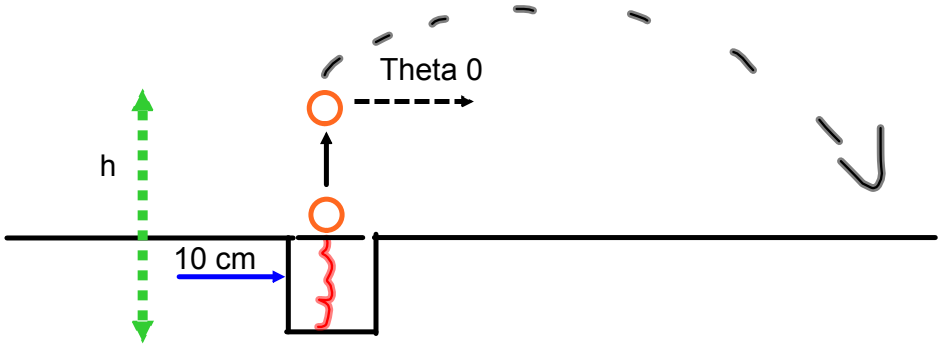
1. A light spring of natural length 10 cm with force constant k = 500 N/m is embedded vertically in the ground. A ball of mass m=0.15kg is placed on top of the spring, which is compressed 8.0cm; when released, the spring pushes the ball. When the ball reaches ground level, it leaves its light supporting platform and continues vertically upward. When it reaches the top of its path, a batter strikes the ball at an angle theta 0 to the horizontal. Ignore air resistance.



a) Find the height h at which the batter strikes the ball

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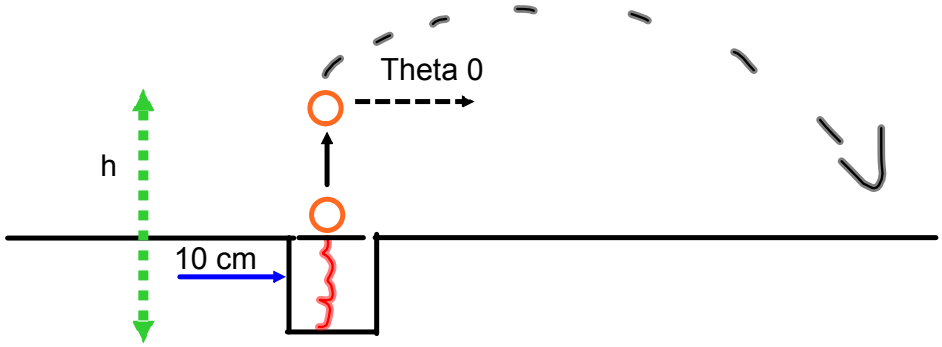

b) if the batter gives the ball an initial velocity of 30 m/s with Theta 0 = 0 by striking the ball with an impact time of 4 ms, determine:

i) the average force exerted on the ball by the bat

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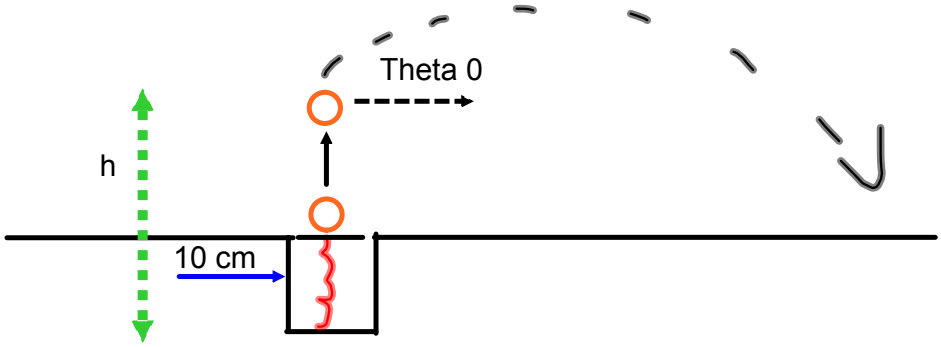

b) if the batter gives the ball an initial velocity of 30 m/s with Theta 0 = 0 by striking the ball with an impact time of 4 ms, determine:

ii) how long the ball is in flight after it's been hit

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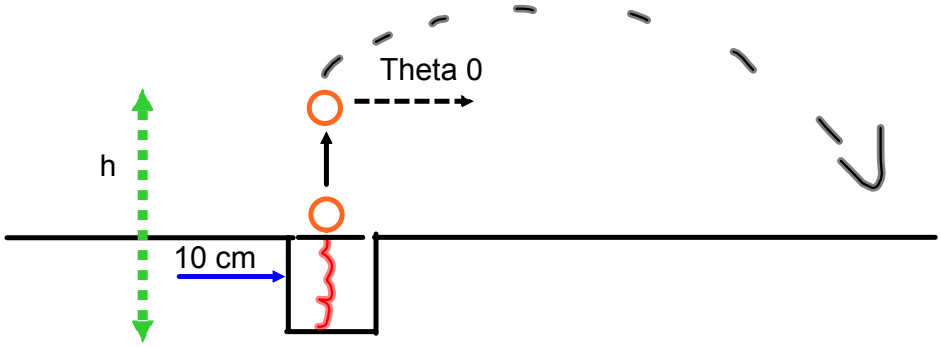

b) if the batter gives the ball an initial velocity of 30 m/s with Theta 0 = 0 by striking the ball with an impact time of 4 ms, determine:

iii) how far the ball travels horizontally

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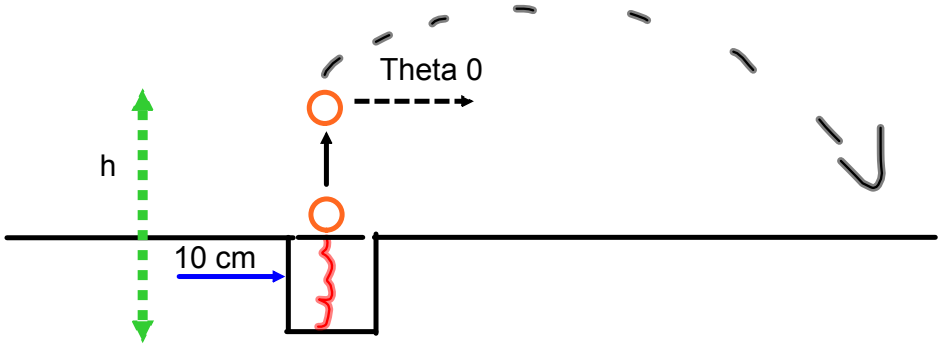
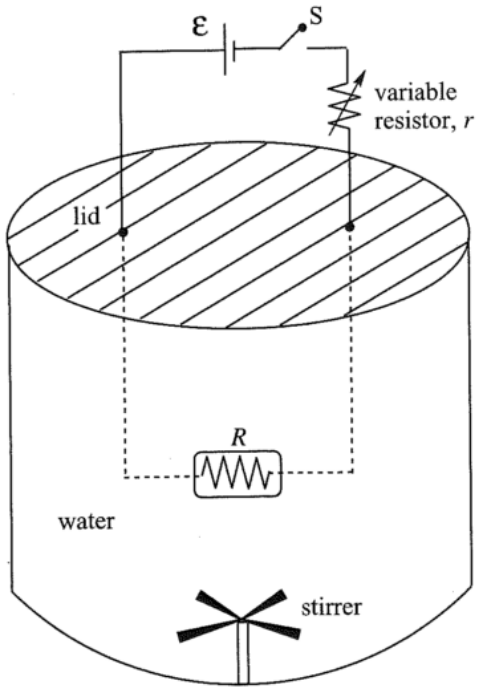


c) If the ball failed to release from the platform, with what frequency would it oscillate?

2) The figure below shows an electric circuit containing a source of emf, E, a variable resistor (r) and a resistor of fixed resistance R is immersed in a sealed beaker containing a mass m of water, currently at temperature T1. When the switch S is closed, current through the circuit causes the resistor in the water to dissipate heat, which is absorbed by the water. A stirrer at the bottom of the beaker simply ensures that the temperature is uniform throughout the water at any given moment. The apparatus is well-insulated (insulation not shown), and it may be assumed that no heat is lost to the walls or lid of the beaker or to the stirrer.

a) Determine the current in the circuit once S is closed. Write your answer in terms of E, r, and R.



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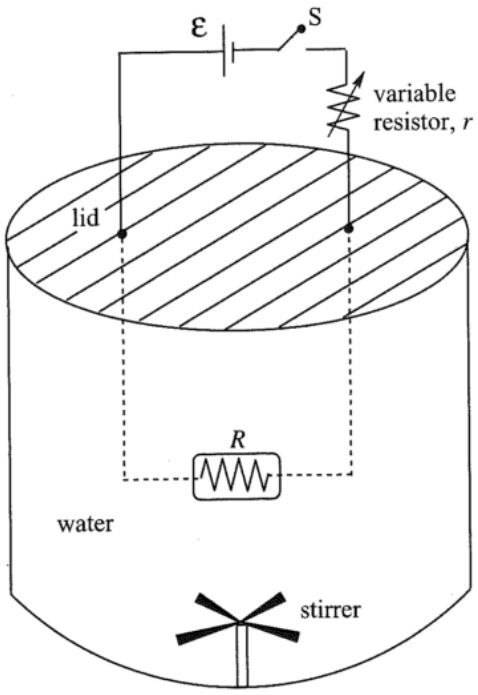
a) How much heat is dissipated by the resistor R in time t?



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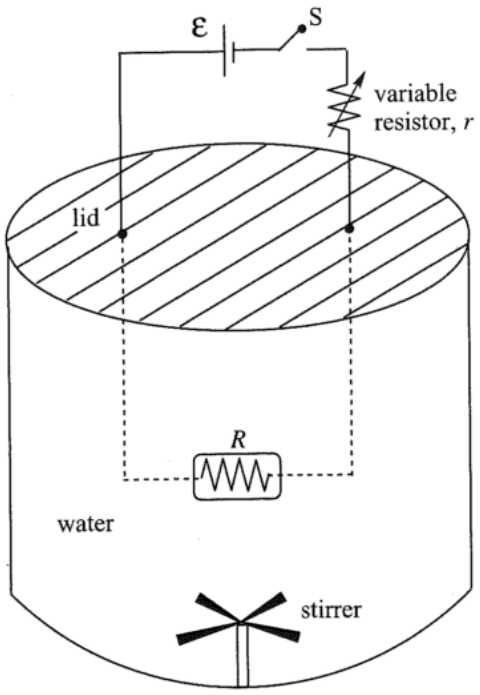
c-i) Give an equation that expresses T, the temperature of the water as a function of time t since turning on the circuit. Write your answer in terms of E, r, R, Ti, m, and c (the specific heat of water).

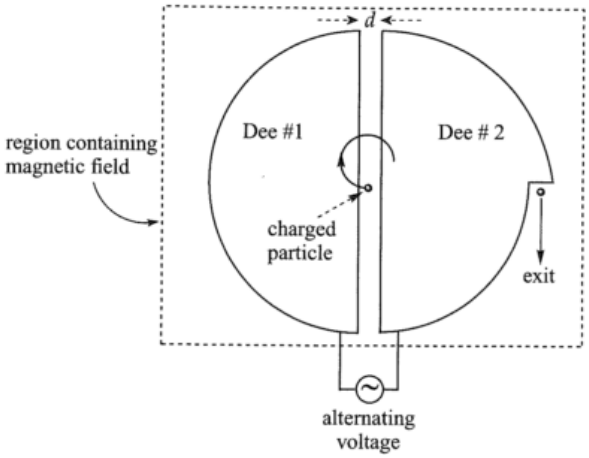


c-ii) On the axes below, provide a sketch of T vs. t. Be sure to mark T=Ti at t=0

d) Explain briefly how the temperature of the water can be increased more rapidly by adjusting the rotation rate of the stirrer.

3) A cyclotron is a device used to accelerate charged particles to high speeds. It consists of two hollow containers - called dees because of their shape - facing each other and separated by a small gap. They are immersed in a uniform magnetic field, B, and are attached to a source of alternating voltage. A charged particle is projected from the center of the cyclotron into Dee #1, and the magnetic force causes it to turn in a circle. When it completes its semicircular path within one dee, the polarity of the voltage is reversed, and the particle is accelerated across the gap into the adjacent dee. This process continues, and the particle spiral outward at faster and faster speeds, until it emerges from Dee #2. Notice that the voltage must be alternated twice during each revolution of the particle. The figure below shows view - looking down from above - of a cyclotron.

a) explain why the electric field in the gap must be used to increase the speed of the particle.



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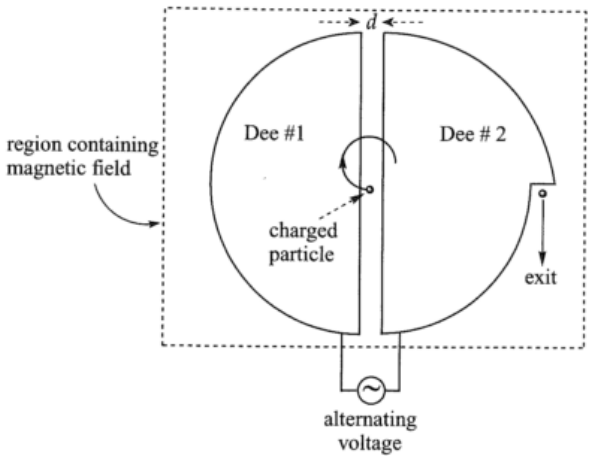
b) Should the magnetic field point into the plane of the page or out of the plane of the page in order to cause the particle to rotate clockwise as shown in the figure?



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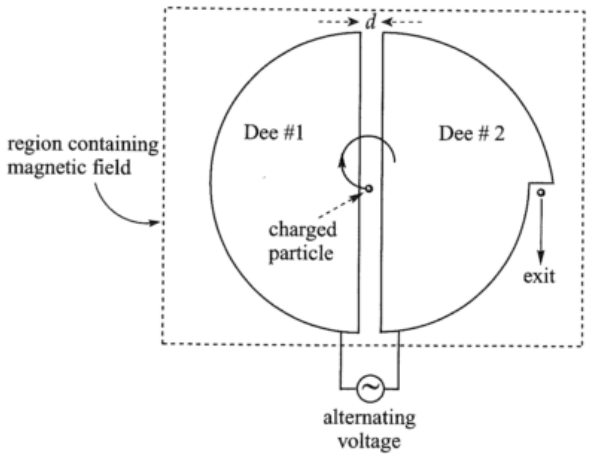
c) Show that the time to complete one revolution does not depend on the speed of the proton, and determine this orbital period.



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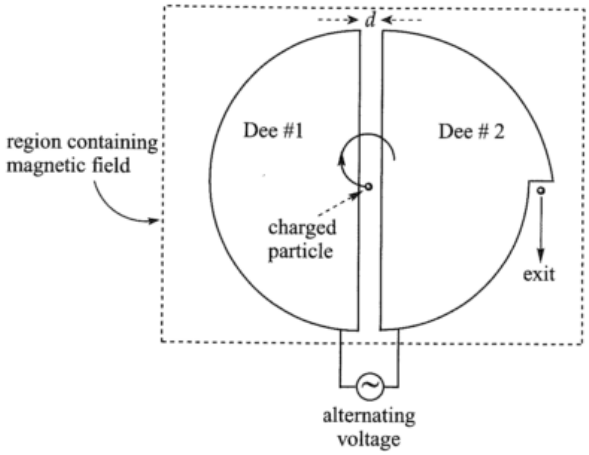
d) How many revolutions does the proton make per second?



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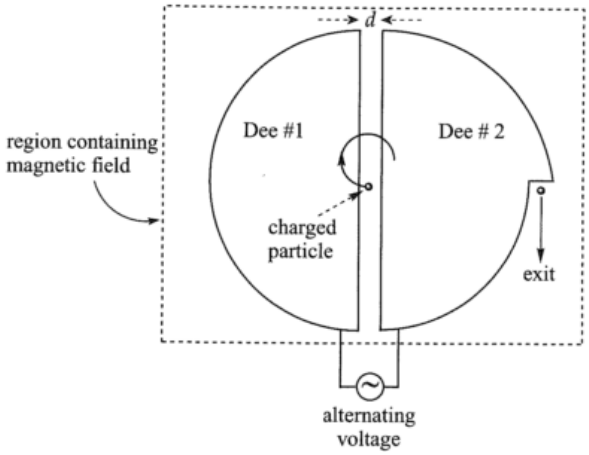
e) What must be the frequency (in Hz) of the alternating voltage?



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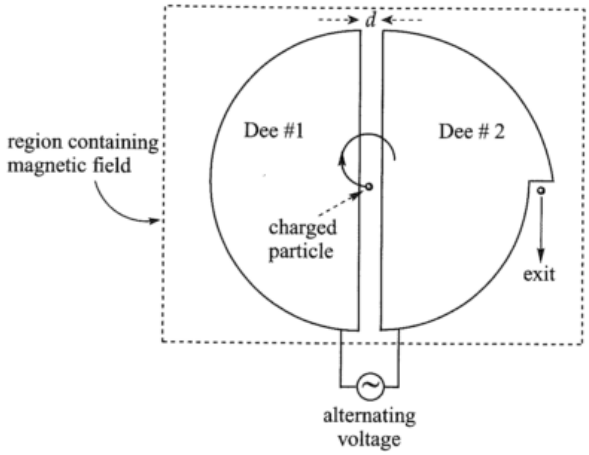
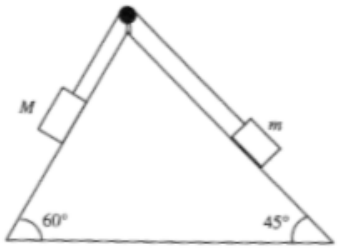
f) If the maximum radius of the proton's orbit is R, what is its maximum kinetic energy upon exiting? (Your answer should also include R.)



4) The figure below shows two boxes attached by a light cord that runs over a frictionless peg. the mass of the block on the 60 degree incline is M = 8 kg, and the mass of the block on the 45 degree incline is m=2kg.

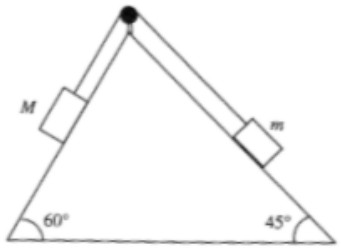
Assume that both inclined surfaces are frictionless for parts (a), (b), and (c)

a) Find the acceleration of the blocks once they are released from rest



4) The figure below shows two boxes attached by a light cord that runs over a frictionless peg. the mass of the block on the 60 degree incline is M = 8 kg, and the mass of the block on the 45 degree incline is m=2kg. Assume that both inclined surfaces are frictionless for parts (a), (b), and (c)

b) What is the total force exerted by the cord on the peg?



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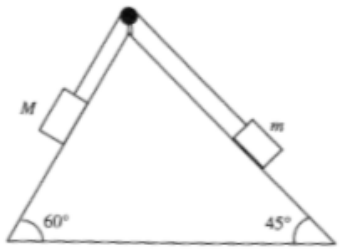
c) If block M is released from rest at a height of H=1.5 m above the bottom of the triangle, find its speed when it reaches the bottom



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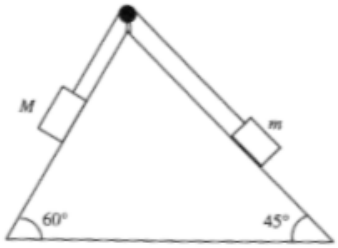
d) Answer the question posed in part (a) assuming that the coefficient of sliding friction between the blocks and the inclined surfaces is 0.2.



5) The figure below is a view from above of two clay balls moving toward each other on a frictionless surface. They collide completely inelastically at the indicated point and are observed to then move in the direction indicated by the post-collision velocity vector, v'. The masses are m1=200g and m2=100g, and the speed of m1 just before impact is v1=6.0 m/s.

a) What is v2?

5) The figure below is a view from above of two clay balls moving toward each other on a frictionless surface. They collide completely inelastically at the indicated point and are observed to then move in the direction indicated by the post-collision velocity vector, v'. The masses are m1=200g and m2=100g, and the speed of m1 just before impact is v1=6.0 m/s.

b) What is v', the common speed of the clay balls immediately after the collision?