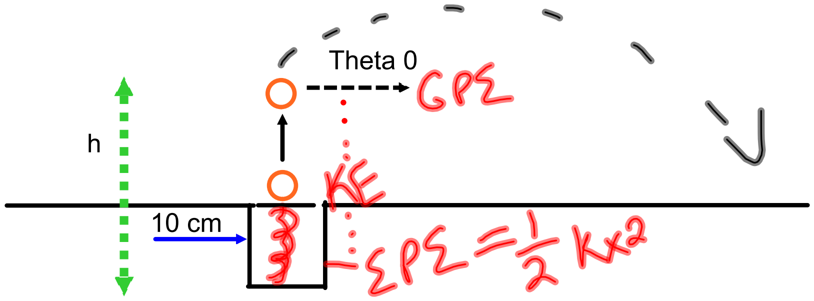
1. A light spring of natural length 10 cm with force constant k = 500 N/m is embedded vertically in the ground. A ball of mass m=0.15kg is placed on top of the spring, which is compressed 8.0cm; when released, the spring pushes the ball. When the ball reaches ground level, it leaves its light supporting 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

$$EPE = GPE$$

$$\frac{1}{2}kx^2 = mgh$$

$$\frac{1}{2}kx^2 = mg(h+0.08m)$$

$$\frac{kx^2}{2mg} - 0.08m = h$$

$$\frac{(500\frac{N}{m})(0.08m)^2}{2(0.15kg)(9.80\,m/s^2)} - 0.08m = h$$

$$h = 1.008m$$

$$\frac{N \quad m^2 \quad s^2}{m \quad kg \quad m}$$

$$\frac{kg \quad m \quad s^2}{s^2 \quad kg}$$

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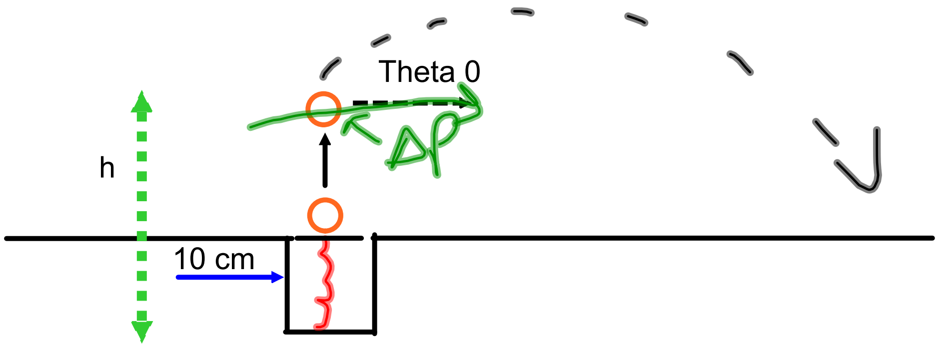

b) if the batter gives the ball an initial velocity of 30 m/s with Theta 0 = 0 by striking the ball with an impact time of 4 ms, determine:

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

$$J = \Delta p$$

$$F \Delta t = \Delta p$$

$$F \Delta t = m \Delta v$$

$$F = \frac{m \Delta v}{\Delta t}$$

$$F = \frac{0.15\,\text{kg}\,(30\,\text{m/s} - 0\,\text{m/s})}{0.004\,\text{s}} \quad 4.0 \times 10^{-3}$$

$$F = 1125\,\text{N}$$

$$1100\,\text{N}$$

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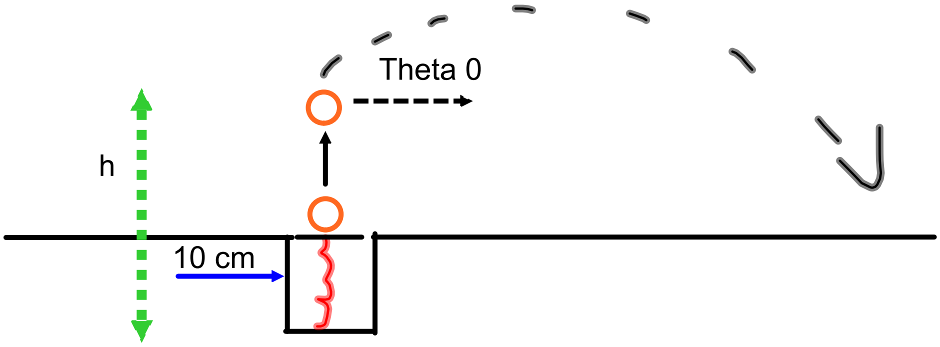


b) if the batter gives the ball an initial velocity of 30 m/s with Theta 0 = 0 by striking the ball with an impact time of 4 ms, determine:

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

$$\Delta y = V_{oy} - \frac{1}{2}gt^2$$

$$\Delta y = -\frac{1}{2}at^2$$

$$h = -\frac{1}{2}at^2$$

$$-h = \frac{1}{2}at^2$$

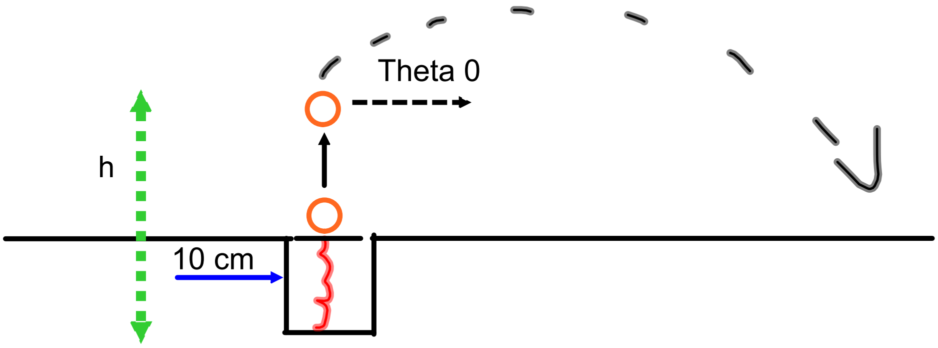
$$-2h = at^2$$

$$\frac{-2h}{a} = t^2 \rightarrow t = \sqrt{\frac{-2h}{a}}$$

$$t = \sqrt{\frac{-2(1.01m)}{-9.80\,m/s^2}}$$

$$t = 0.45s$$

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.



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

$t = 0.45\,s$

$\Delta x = V_x t$

$\Delta x = (30\,m/s)(0.45\,s)$

$\Delta x = 13.5$

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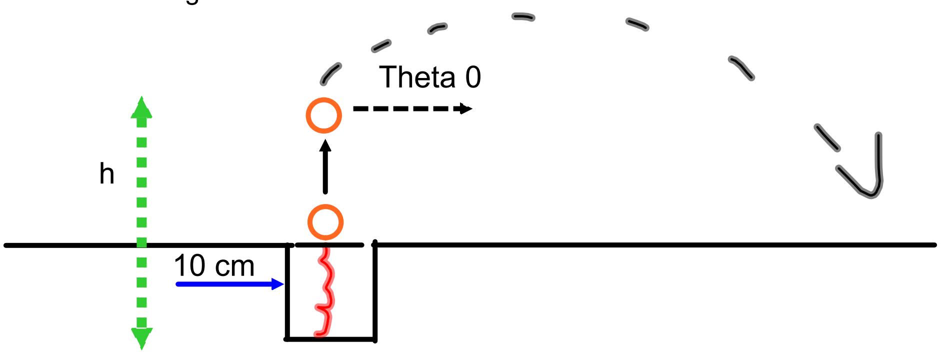


c) If the ball failed to release from the platform, with what frequency would it oscillate?

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

$$f = \frac{1}{2\pi}\sqrt{\frac{500\,N/m}{0.15\,kg}}$$

$$f = 9.2\,Hz$$

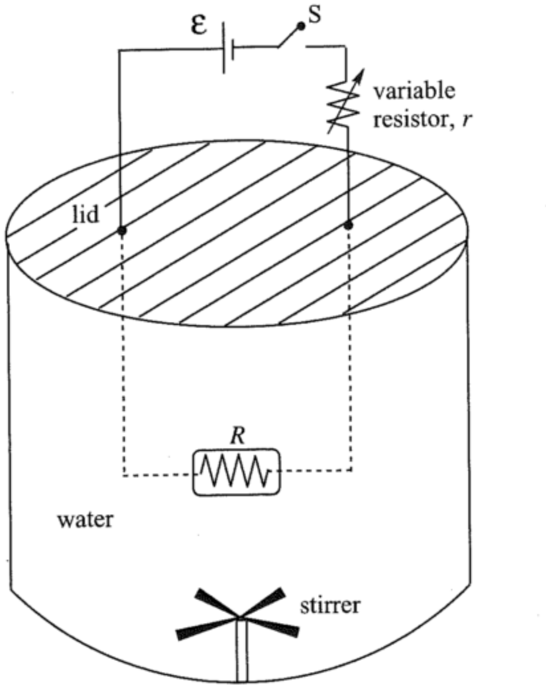
2) The figure below shows an electric circuit containing a source of emf, E, a variable resistor (r) and a resistor of fixed resistance R is immersed in a sealed beaker containing a mass m of water, currently at temperature T1. When the switch S is closed, current through the circuit causes the resistor 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.

$V = IR$

$I = \frac{V}{R} \rightarrow \frac{V}{(r+R)}$

$I = \frac{\varepsilon}{(r+R)}$



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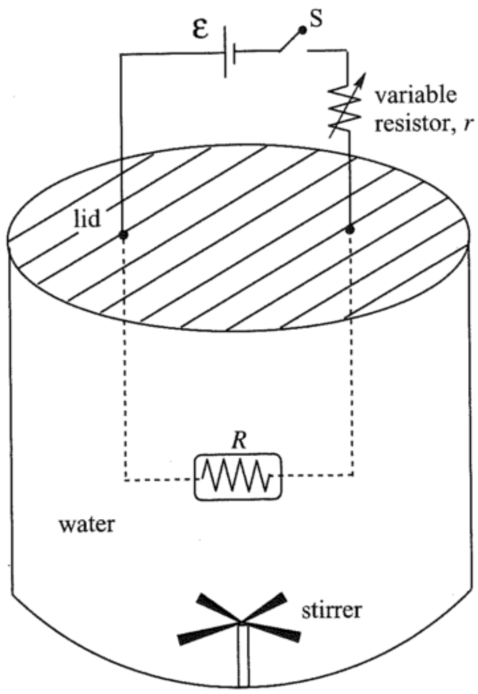
a) How much heat is dissipated by the resistor R in time t?

$$I = \frac{\varepsilon}{(r+R)} \qquad Pt$$

$$Q = I^2 R t$$

$$Q = \left(\frac{\varepsilon}{(r+R)}\right)^2 R$$

$$Q = \frac{\varepsilon^2 R t}{(r+R)^2}$$



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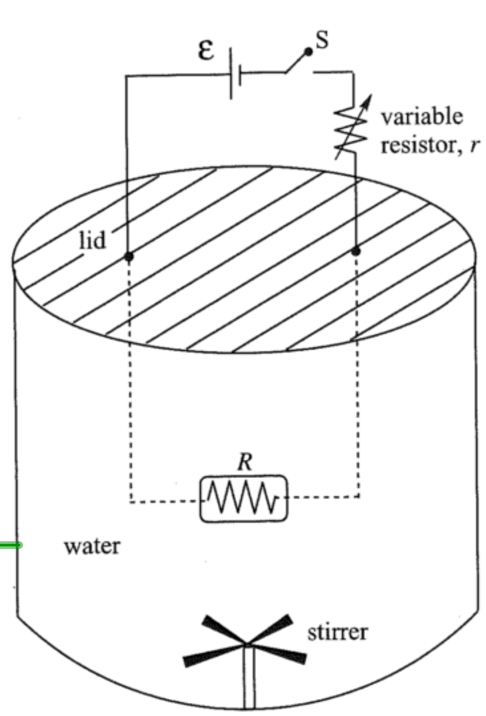
c-i) Give an equation that expresses T, the temperature of the water as a function of time t since turning on the circuit. Write your answer in terms of E, r, R, Ti, m, and c (the specific heat of water).

$Q = cm\Delta t$

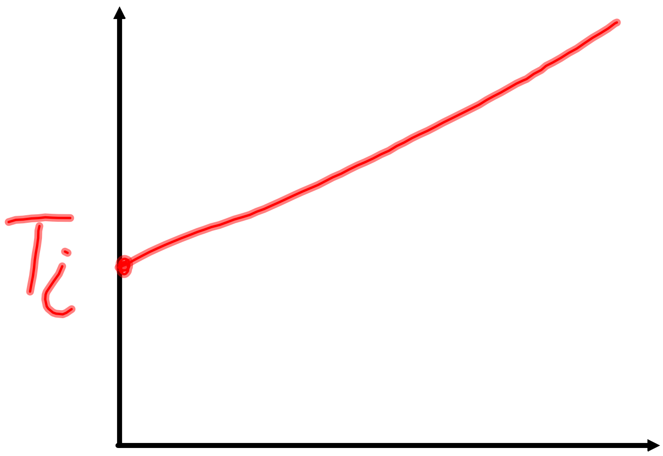
$\frac{\varepsilon^2 R t}{(r+R)^2} = cm\Delta t$

$T - T_i$

$T = \frac{\varepsilon^2 R t}{(r+R)^2 cm} + T_i = T$



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



$T = \frac{\varepsilon^2 R t}{(r+R)^2 cm} + T_i$

$T = t$

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