Physics 30 - Lesson 3C
Conservation of Energy

1) /2 The claim that less work is done is not valid. Work is the change in an object's energy, in this case gravitational potential energy. Using a ramp or going straight up results in the same change in energy. However the amount of force required is less for the ramp since the distance is longer (W = Fd).

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2) /2 Assuming that the same friction force acts on each car, the car with the longer skid mark had twice the kinetic energy of the other car ($W = \Delta E = Fd$).

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3) /5

a. non-mechanical
b. mechanical (kinetic energy of air molecules)
c. mechanical (alternating gravitational potential and kinetic energies)
d. mechanical (there is spring potential in the mattress)
e. mechanical (the rocket has kinetic and gravitational potential energies)

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4) /2 No it is not possible. The ball has gravitational potential energy when it is dropped. It can not gain energy some how in the act of falling and bouncing up. In fact, some energy will be lost as heat in the collision with the earth.

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5) /4

$$E_k = \frac{mv^2}{2} = \frac{(1250\text{kg})(11\text{m/s})^2}{2}$$

$$E_k = \mathbf{7.6 \times 10^4\ J}$$

$$v = \sqrt{\frac{2E_k}{m}} = \sqrt{\frac{2(7.6 \times 10^4\ \text{J})}{0.55 \times 10^{-3}\ \text{kg}}}$$

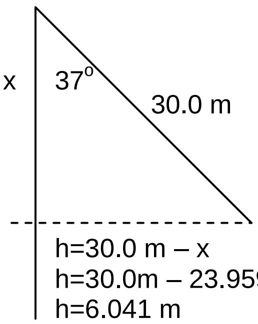
$$v = \mathbf{1.7 \times 10^4\ m/s}$$

6)

/8

x=30.0cos37°

x=23.959m



h=30.0 m – x

h=30.0m – 23.959m

h=6.041 m

a. from rest

$$E_k = E_p$$

$$\frac{\cancel{m}v^2}{2} = \cancel{m}gh$$

$$v = \sqrt{2gh} = \sqrt{2(9.81m/s^2)(6.041m)}$$

$$v = \mathbf{10.9\,m/s}$$

b. starts at 4.00 m/s

$$E_k = E_p + E_{ki}$$

$$\frac{\cancel{m}v^2}{2} = \cancel{m}gh + \frac{\cancel{m}v_i^2}{2}$$

$$v = \sqrt{2gh + v_i^2}$$

$$v = \sqrt{2(9.81m/s^2)(6.041m) + (4.00m/s)^2}$$

$$v = \mathbf{11.6\,m/s}$$

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7)

/6

a. frictional force

$$W = \Delta E_k$$

$$W = E_{kf} - E_{ki}$$

$$Fd = 0 - \frac{mv^2}{2}$$

$$F = -\frac{mv^2}{2d} = -\frac{0.00500kg(600.0m/s)^2}{2(0.0400m)}$$

$$F = -\mathbf{2.25 \times 10^4\,N}$$

b. stopping time

$$d = \frac{v_i + v_f}{2}\Delta t$$

$$\Delta t = \frac{2d}{v_i + v_f} = \frac{2(0.0400m)}{600.0m/s + 0}$$

$$\Delta t = \mathbf{1.33 \times 10^{-3}\,s}$$

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8)

/4

$$\Sigma E_i = \Sigma E_f$$

$$E_{p\,spring} = E_{p\,grav}$$

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

$$h = \frac{kx^2}{2mg} = \frac{(5.00 \times 10^3 N/m)(0.100m)^2}{2(0.250kg)(9.81m/s^2)}$$

$$h = \mathbf{10.2\,m}$$

9) /5

a. From the graph ~120 mJ.

b. From the graph E_k ~ 350 mJ

$$E_k = \frac{mv^2}{2}$$

$$v = \sqrt{\frac{2E_k}{m}} = \sqrt{\frac{2(350\times10^{-3}\,J)}{75\times10^{-3}\,kg}}$$

$$v \approx \mathbf{3.1 m/s}$$

c. From the graph $E_{P\,max}$ = 600 mJ

$$E_p = mgh$$

$$h = \frac{E_p}{mg} = \frac{0.600J}{(0.075kg)(9.81m/s^2)}$$

$$h = \mathbf{82\,cm}$$

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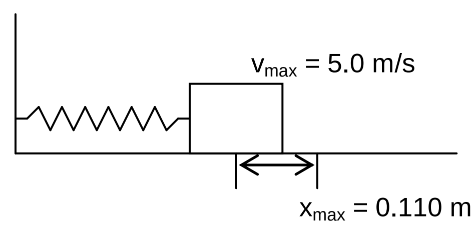
10) /3

$$E_{k_{max}} = E_{p_{max}}$$

$$\tfrac{1}{2}mv_{max}^2 = \tfrac{1}{2}kx_{max}^2$$

$$k_{max} = \frac{mv_{max}^2}{x^2} = \frac{(4.0kg)(5.0m/s)^2}{(0.110m)^2}$$

$$k = \mathbf{8.3\times10^3\,N/m}$$



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11) /6

First, find m

$$E_{k_{max}} = E_{p_{max}}$$

$$\tfrac{1}{2}mv_{max}^2 = \tfrac{1}{2}kx_{max}^2$$

$$m = \frac{kx^2}{v^2} = \frac{18N/m(0.29m)^2}{(0.35m/s)^2}$$

$$m = 12.4\,kg$$

Second, calculate the speed when x = 0.20 m

$$E_{p\,max} = E_k + E_p$$

$$\tfrac{1}{2}kx_{max}^2 = \tfrac{1}{2}mv^2 + \tfrac{1}{2}kx^2$$

$$mv^2 = kx_{max}^2 - kx^2$$

$$v = \sqrt{\frac{k(x_{max}^2 - x^2)}{m}}$$

$$v = \sqrt{\frac{18N/m(0.29m^2 - 0.20m^2)}{12.4kg}}$$

$$v = \mathbf{0.25\,m/s}$$

12)

/9

$$E_T = E_k + E_p = \tfrac{1}{2}mv^2 + \tfrac{1}{2}kx^2$$
$$E_T = \tfrac{1}{2}(0.750kg)(0.250m/s)^2 + \tfrac{1}{2}(995N/m)(0.145m)^2$$
$$E_T = 10.0J$$

$$E_{p_{max}} = E_T$$
$$\tfrac{1}{2}kx_{max}^2 = E_T$$
$$x_{max} = \sqrt{\frac{2E_T}{k}}$$
$$x_{max} = \sqrt{\frac{2(10.0J)}{995N/m}}$$
$$x_{max} = \mathbf{0.145\,m}$$

$$E_{k_{max}} = E_T$$
$$\tfrac{1}{2}mv_{max}^2 = E_T$$
$$v_{max} = \sqrt{\frac{2E_T}{m}}$$
$$v_{max} = \sqrt{\frac{2(10.0J)}{0.750kg}}$$
$$v_{max} = \mathbf{5.17\,m/s}$$

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13)

/9

$$E_T = E_k + E_p = \tfrac{1}{2}mv^2 + mgh$$
$$E_T = \tfrac{1}{2}(1.35kg)(2.40m/s)^2 + 1.35kg(9.81)(0.85m)$$
$$E_T = 15.14\,J$$

$$E_{k_{max}} = E_T$$
$$\tfrac{1}{2}mv_{max}^2 = E_T$$
$$v_{max} = \sqrt{\frac{2E_T}{m}}$$
$$v_{max} = \sqrt{\frac{2(15.14J)}{1.35kg}}$$
$$v_{max} = \mathbf{4.74\,m/s}$$

$$T = 2\pi\sqrt{\frac{l}{g}}$$
$$T = 2\pi\sqrt{\frac{3.20\,m}{9.81N/m}}$$
$$T = \mathbf{3.59\,s}$$

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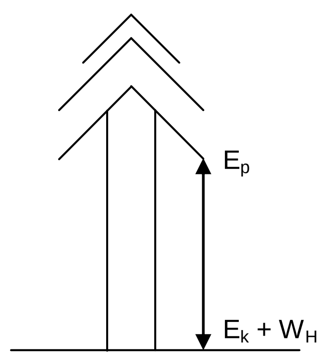
14)

/6

a) no air resistance

$$E_k = E_p$$
$$\tfrac{1}{2}mv^2 = mgh$$
$$v = \sqrt{2gh} = \sqrt{2(9.81m/s^2)(20m)}$$
$$v = \mathbf{20\,m/s}$$



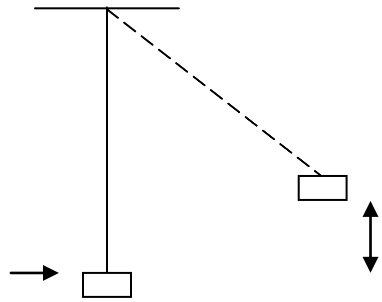
b) with air resistance

$$E_p = E_k + W_H$$
$$mgh = \tfrac{1}{2}mv^2 + F_f d$$
$$F_f = \frac{mgh - \tfrac{1}{2}mv^2}{d} = \frac{(0.25kg)(9.81)(20m) - \tfrac{1}{2}(0.25)(9.0)^2}{20m}$$
$$F_f = \mathbf{1.9\,N}$$

15) Since the collision between the bullet and the pendulum is inelastic kinetic energy is not conserved. Therefore the problem can be solved in two parts:

/6 a. the swing up > energy

b. the collision > momentum



$$E_k = E_p$$

$$\tfrac{1}{2}mv'^2 = mgh$$

$$v' = \sqrt{2gh} = \sqrt{2(9.81\,m/s^2)(0.065\,m)}$$

$$v' = 1.13\,m/s$$

$$\sum p_{before} = \sum p_{after}$$

$$m_b v_b = (m_b + m_B)v'$$

$$v_b = \frac{(m_b + m_B)v'}{m_b} = \frac{(5.0g + 500g)1.13\,m/s}{5.0g}$$

$$v_b = \mathbf{114\,m/s}$$

16) $\sum$ energy before = $\sum$ energy after

/4

$$E_{p12} = E_{p4} + E_{k12} + E_{k4}$$

$$m_{12}gh = m_4gh + \tfrac{1}{2}m_{12}v^2 + \tfrac{1}{2}m_4v^2$$

$$m_{12}gh = m_4gh + v^2\left(\tfrac{1}{2}m_{12} + \tfrac{1}{2}m_4\right)$$

$$v = \sqrt{\frac{m_{12}gh - m_4gh}{\tfrac{1}{2}m_{12} + \tfrac{1}{2}m_4}}$$

$$v = \sqrt{\frac{(12.0kg - 4.0kg)(9.81)(5.00)}{\tfrac{1}{2}(12.0kg) + \tfrac{1}{2}(4.0kg)}}$$

$$v = \mathbf{7.0\,m/s}$$