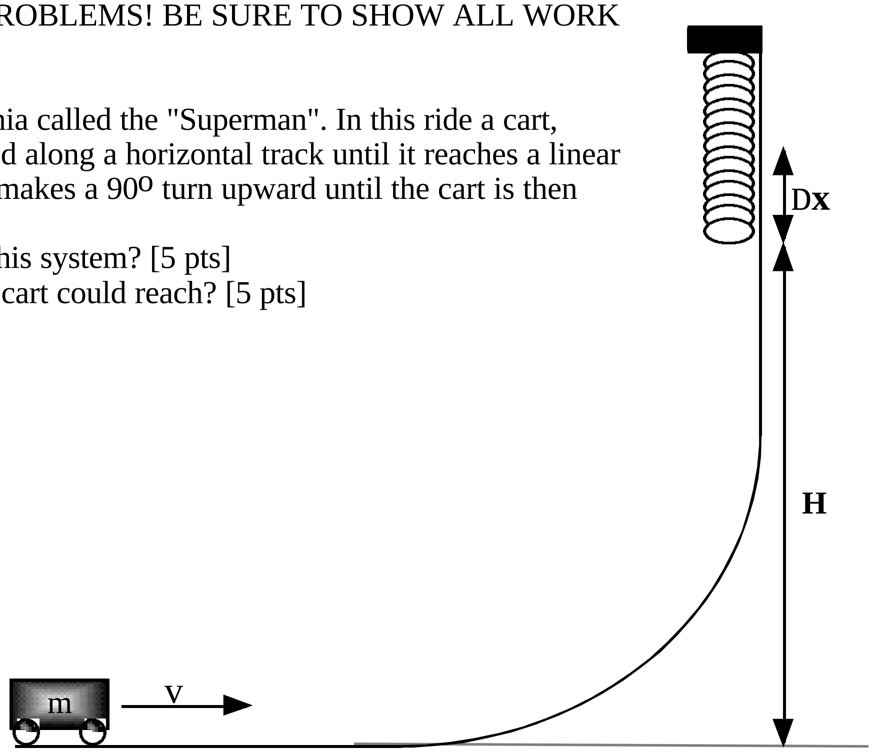
LAB PHYSICS - TEST CHAPTER 6[D] ENERGY CONSERVATION 1998-99 D

ANSWER EACH OF THE FOLLOWING PROBLEMS! BE SURE TO SHOW ALL WORK CAREFULLY!

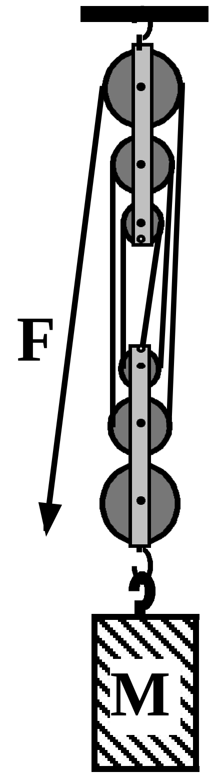
1. Consider a new amusement ride in California called the "Superman". In this ride a cart, which has a mass of 1750 kg., is accelerated along a horizontal track until it reaches a linear velocity of v = 46.0 m/sec. The track then makes a 90^o turn upward until the cart is then heading straight up.
   a. What is the total mechanical energy of this system? [5 pts]
   b. What is the maximum height h that this cart could reach? [5 pts]



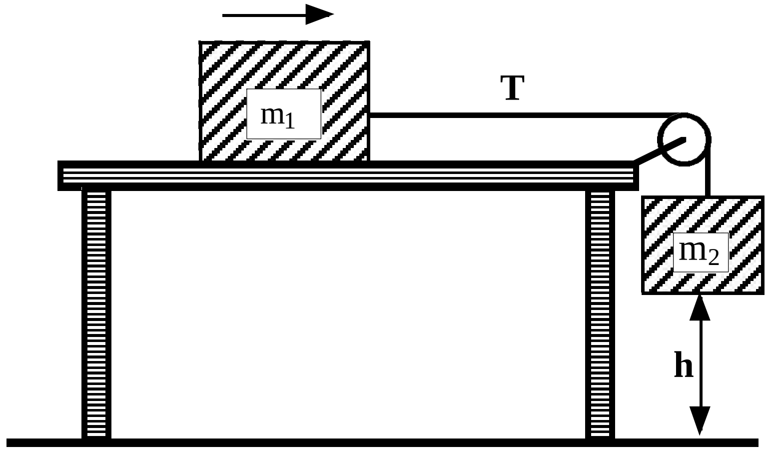
At a height of H = 75 meters there is a spring which has a spring constant of k = 145,000 N/m. The cart runs into the spring and is quickly brought to rest.

c. What will be the kinetic energy of the car just as it reaches the lower end of the spring? [5 pts]
d. What will be the speed of the cart just as it reaches the lower end of the spring? [5 pts]
e. How much will the spring be compressed when the cart briefly comes to rest against the spring? [5 pts]
f. What will be the gravitational potential energy of the cart when it briefly comes to rest against the spring? [5 pts]

2. A simple machines consists of a system of pulleys lifting a load of M = 245 kg. An input force of F = 620 N is applied to the so as to lift the load a distance of 1.40 meters.
   a. What is the ideal mechanical advantage of this machine? [5 pts]
   b. What is the actual mechanical advantage of this machine? [4 pts]
   c. What is the work output of this machine? [4 pts]
   d. Through what distance must the input force be applied to lift the load to the given height? [4 pts]
   e. What is the efficiency of this simple machine? [4 pts]
   f. How much energy was wasted in lifting the load to the given height? [4 pts]



3. A mass m_1 = 7.5 kg is sitting on a table as shown to the right. A string is then attached to m_1, hung over a pulley and is then attached to a second mass m_2 = 5.25 kg. which is initially h = 85.0 cm above the floor. [Assume initially that the surface of the table is frictionless and that the floor is h = 0.] The system is released and m_2 is allowed to accelerate toward the floor.



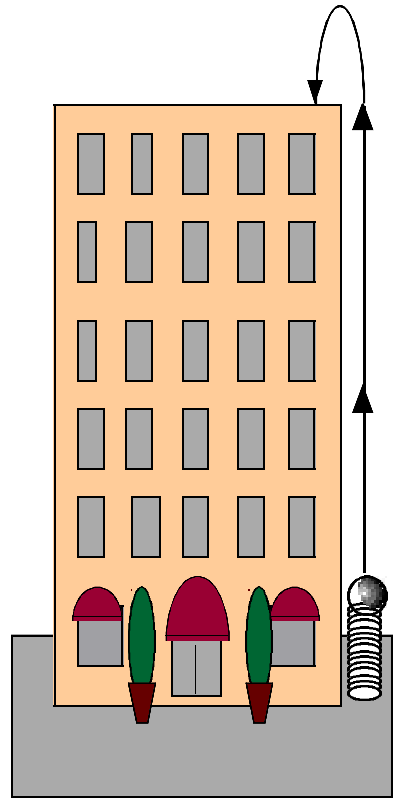
a. What is the initial mechanical energy of this system? [5 pts]
b. What will be the kinetic energy of this system just as m_2 reaches the floor? [5 pts]
c. What will be the velocity of m_2 just as it reaches the floor? [5 pts]

Suppose instead that the coefficient of friction between the mass m_1 and the table top is m = 0.260.

d. How much work will be done against the frictional force as m_2 falls to the floor? [5 pts]
e. What will be the velocity of m_2 just as it reaches the floor? [5 pts]

4. A rocket, which has a mass of 87,000 kg is to be launched from the surface of Triton [$m_{Triton} = 1.34 \times 10^{23}$ kg, $r_{Triton} = 1.90 \times 10^{6}$ m, $G = 6.67 \times 10^{-11}$ Nm^2/kg^2]
   a. What will be the total gravitational energy of this rocket while sitting on the surface of Triton? [5 pts]
   b. With what velocity must this rocket be launched from the surface of Triton in order for it to escape the gravitational effect of Triton? [4 pts]
   c. Suppose that this rocket is launched from the surface of Triton with a velocity of 5.5×10^{3} m/sec., what will be the velocity of this rocket when it is very far from Triton? [4 pts]
   Suppose that this rocket is orbiting Triton at an altitude of 1.2×10^{6} meters.
   d. What velocity is required to orbit Triton at this altitude? [4 pts]
   e. What will be the total energy content of the rocket as it orbits Triton at this altitude? [4 pts]
   f. How much energy must be added to this rocket if it is to escape the gravitational force of Triton from this orbit? [4 pts]

5. A ball, which has a mass of 1.15 kg, is compressed a distance of 18.0 cm against a spring which has a constant of k = 185,000 N/m. The ball is then released, flies up into the air, and lands of the roof of a building which is h = 185 meters tall. What will be the speed of the ball as it lands on the roof of the building? [5 pts]



1. $m_{cart} := 1750 \cdot kg$ $v_o := 46.0 \cdot \frac{m}{sec}$ $h := 75 \cdot m$ $v_f := 1 \cdot \frac{m}{sec}$ $\Delta x := 1 \cdot m$ $k := 145000 \cdot \frac{N}{m}$

a. $KE_o := \frac{1}{2} \cdot m_{cart} \cdot v_o^{2}$ $KE_o = 1.85 \times 10^{6}\ J$ **1a. The initial total energy of this system. [5 pts]**

b. Given $m_{cart} \cdot g \cdot h = KE_o$ $h := Find(h)$ $h = 107.89\ m$ **1b. The maximum height the cart can reach. [4 pts]**

c. $H := 75 \cdot m$ $k := 105000 \cdot \frac{N}{m}$ $KE := KE_o - m_{cart} \cdot g \cdot H$ $KE = 5.64 \times 10^{5}\ J$ **1c. The kinetic energy of the cart just as it reaches the spring. [4 pts]**

d. Given $\frac{1}{2} \cdot m_{cart} \cdot v_f^{2} = KE$ $v_f := Find(v_f)$ $v_f = 25.40 \frac{m}{sec}$ **1d. The velocity of the cart just as it reaches the end of the spring. [4 pts]**

e. Given $KE_o = \frac{1}{2} \cdot k \cdot \Delta x^{2} + m_{cart} \cdot g \cdot (H + \Delta x)$

$\Delta x := Find(\Delta x)$ $\Delta x = 3.12\ m$

f. $GPE := m_{cart} \cdot g \cdot (H + \Delta x)$ $GPE = 1.34 \times 10^{6}\ J$ **1f. The gravitational potential energy of the cart when it comes to rest against the spring. [4 pts]**

2. $M := 245 \cdot kg$ $F_{in} := 620 \cdot N$ $d_o := 1.40 \cdot m$ **a.** $IMA := 5$ **2a. The IMA of this machine. [6 pts]**

b. $F_{out} := M \cdot g$ $F_{out} = 2.40 \times 10^{3}\ N$ $AMA := \frac{F_{out}}{F_{in}}$ $AMA = 3.88$ **2b. The AMA of this machine. [6 pts]**

c. $W_{out} := F_{out} \cdot d_o$ $W_{out} = 3.36 \times 10^{3}\ J$ **2c. The wok output of this machine. [6 pts]**

d. $d_{in} := d_o \cdot IMA$ $d_{in} = 7.00\ m$ **2d. The distance through which the input force must be applied. [6 pts]**

e. $W_{in} := F_{in} \cdot d_{in}$ $W_{in} = 4.34 \times 10^{3}\ J$ $EFF := \frac{W_{out}}{W_{in}}$ $EFF = 77.50\ \%$ **2e. The efficiency of this simple machine. [6 pts]**

f. $W_{wasted} := W_{in} - W_{out}$ $W_{wasted} = 976.32\ J$ **2f. The energy wasted in lifting M. [6 pts]**

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3. $m_1 := 7.50 \cdot kg$ $m_2 := 5.25 \cdot kg$ $h := 85.0 \cdot cm$ $v_f := 1 \cdot \frac{m}{sec}$

a. $GPE := m_2 \cdot g \cdot h$ $GPE = 43.76\,J$ **1a. The initial total energy of this system. [5 pts]**

b. $KE_f := GPE$ $KE_f = 43.76\,J$ **1b. The kinetic energy of the system just as m_2 reaches the floor. [5 pts]**

c. Given $KE_f = \frac{1}{2} \cdot (m_1 + m_2) v_f^2$ $v_f := Find(v_f)$ $v_f = 2.62 \frac{m}{sec}$ **1c. The final velocity of m_2 as it strikes the ground. [5 pts]**

d. $\mu := 0.260$ $F_f := m_1 \cdot g \cdot \mu$ $F_f = 19.12\,N$ $W_{Ff} := F_f \cdot h$ $W_{Ff} = 16.25\,J$ **1d. The work done against the force of friction. [5 pts]**

e. $KE_f := GPE - W_{Ff}$ $KE_f = 27.51\,J$ $v_f := \sqrt{\frac{2 \cdot KE_f}{m_1 + m_2}}$ $v_f = 2.08 \frac{m}{sec}$ **1e. The final velocity of the system. [5 pts]**

4. $m_{triton} := 1.34 \cdot 10^{23} \cdot kg$ $r_{triton} := 1.9 \cdot 10^{6} \cdot m$ $G := 6.67 \cdot 10^{-11} \frac{N \cdot m^2}{kg^2}$ $m_{rocket} := 87000 \cdot kg$

a. $GPE_o := \frac{-G \cdot m_{triton} \cdot m_{rocket}}{r_{triton}}$ $GPE_o = -4.09 \times 10^{11}\,J$ **4a. The initial energy of the rocket. [5 pts]**

b. $v_{esc} := \sqrt{\frac{2 \cdot G \cdot m_{triton}}{r_{triton}}}$ $v_{esc} = 3.07 \times 10^{3} \frac{m}{sec}$ **4b. The escape velocity. [4 pts]**

c. $v_o := 5.5 \cdot 10^{3} \cdot \frac{m}{sec}$ $v_{far} := 10^{3} \cdot \frac{m}{sec}$ Given $\frac{1}{2} \cdot m_{rocket} \cdot v_o^2 - \frac{G \cdot m_{rocket} \cdot m_{triton}}{r_{triton}} = \frac{1}{2} \cdot m_{rocket} \cdot v_{far}^2$

$v_{far} := Find(v_{far})$ $v_{far} = 4.57 \times 10^{3} \frac{m}{sec}$ **4c. The velocity far away. [4 pts]**

d. $alt := 1.2 \cdot 10^{6} \cdot m$

$v_{orbit} := \sqrt{\frac{G \cdot m_{triton}}{r_{triton} + alt}}$ $v_{orbit} = 1.70 \times 10^{3} \frac{m}{sec}$ **4d. The orbital velocity. [4 pts]**

e. $TE_{orbit} := \frac{1}{2} \cdot m_{rocket} \cdot v_{orbit}^2 - \frac{G \cdot m_{triton} \cdot m_{rocket}}{r_{triton} + alt}$ $TE_{orbit} = -1.25 \times 10^{11}\,J$ **4e. The orbital energy. [4 pts]**

f. $Energy_{added} := -TE_{orbit}$ $Energy_{added} = 1.25 \times 10^{11}\,J$ **4f. Energy added to escape orbit. [4 pts]**