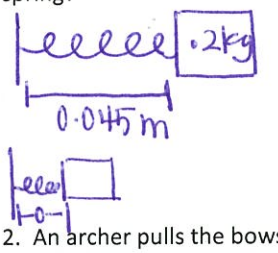
Elastic Energy Problems

Name KEY
Period _____ Date _____

1. A block of mass 0.2 kg is attached to a spring and is oscillating horizontally on a frictionless table. The spring (545 N/m) is initially stretched by 0.045 m and then released from rest. How fast is the block moving when it reaches the equilibrium position of the spring?



$EPE_i + KE_i = EPE_f + KE_f$

0 (not moving) 0 (not stretched)

$\frac{1}{2}kx^2 = \frac{1}{2}mv^2$ $\frac{1}{2}(545\ N/m)(0.045m)^2 = \frac{1}{2}(0.2kg)(v^2)$

2.35 m/s

2. An archer pulls the bowstring back for a distance of 0.47 m before releasing the arrow. The bow and string act like a spring whose spring constant is 425 N/m.

(a) What is the elastic energy of the drawn bow?

$EPE = \frac{1}{2}kx^2 = \frac{1}{2}(425\ N/m)(0.47m)^2 =$

47 J

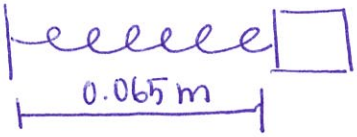
(b) The arrow has a mass of 0.03 kg. How fast is it traveling when it leaves the bow?

$EPE_i = KE_f$ $47\ J = \frac{1}{2}(0.03kg)(v^2)$

56 m/s

3. A horizontal spring (360 N/m) is lying on a frictionless surface. One end of the spring is attached to a wall, and the other end is connected to an object of mass 2.8 kg. The spring is then compressed by 0.065 m and released from rest. What is the speed of the object at the instant when the spring is stretched by 0.048 m relative to its unstrained length?

I:



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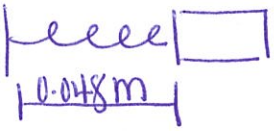
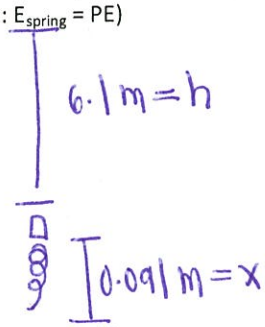


$EPE_i + KE_i = EPE_f + KE_f$

$\frac{1}{2}(360\ N/m)(0.065m)^2 = \frac{1}{2}(360\ N/m)(0.048m)^2 + \frac{1}{2}(2.8kg)(v^2)$

0.5 m/s

4. A rifle fires a 0.021-kg pellet straight upward, because the pellet rests on a compressed spring that is released when the trigger is pulled. The spring has a negligible mass and is compressed by 0.091 m from its unstrained length. The pellet rises to a height of 6.1 m above its position on the compressed spring. Determine the spring constant.
(hint: E_{spring} = PE)



$EPE_i = GPE_f$

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

$\frac{1}{2}(k)(0.091m)^2 = (0.021kg)(10\ m/s^2)(6.1m)$

309 N/m

5. A paratrooper fell 370 m after jumping from an aircraft without his parachute opening. He landed in a snowbank, creating a crater 1.1 m deep, surviving with minor injuries. Assuming the paratrooper's mass was 80 kg and his terminal velocity through the air was 30 m/s, find

(a) the work done by the snow in bringing him to rest; *36,000 J*

$W = \Delta KE = \frac{1}{2}m(v_f - v_i)^2$

$= \frac{1}{2}(80\text{kg})(0 - 30\text{m/s})^2$

(b) the average force exerted on him by the snow to stop him; 32,700 N ~~32,700 J~~

$W = F \cdot d \quad F = \frac{W}{d} = \frac{36000\text{ J}}{1.1\text{ m}}$

(c) the work done on him by air resistance as he fell; and 260,000 J ~~260,00 N~~

TOTAL $W = \Delta E$ (from top) $= \Delta GPE = (370\text{m})(10\text{m/s}^2)(80\text{kg})$

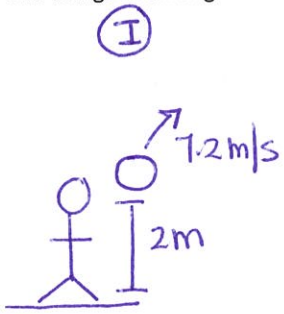
$= 296000\text{ J} - \Delta KE$ (from d)

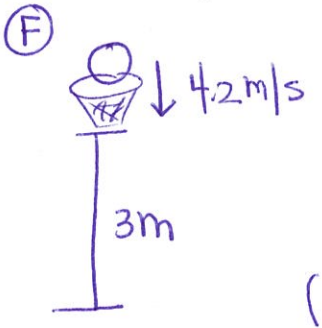
$= 296000\text{ J} - 36000\text{ J} = 260,000\text{ J}$

(d) the average force exerted on him by the air while he was falling. *702 N*

$W = F \cdot d \quad F = \frac{W}{d} = \frac{260,000\text{ J}}{370\text{ m}} =$

6. A basketball player makes a jump shot. The 0.6-kg ball is released at a height of 2.0 m above the floor with a speed of 7.2 m/s. The ball goes through the net 3.0 m above the floor at a speed of 4.2 m/s. How much work was done on the ball by air resistance? *4.3 J*





$E_I = E_F$

$GPE_i + KE_i = GPE_f + KE_f + W$

$mgh_i + \frac{1}{2}mv_i^2 = mgh_f + \frac{1}{2}mv_f^2 + W$

$(.6\text{kg})(10\text{m/s}^2)(2\text{m}) + \frac{1}{2}(.6\text{kg})(7.2\text{m/s})^2 =$

$(.6\text{kg})(10\text{m/s}^2)(3\text{m}) + \frac{1}{2}(.6\text{kg})(4.2\text{m/s})^2 + W$

Hints:
3. $E_{spring\ compressed} = E_{spring\ stretched} + KE$
5c. $W = \Delta E = PE\text{-}KE = mgh - \frac{1}{2}mv^2$
6. $E_1 - W_{air} = E_2 \rightarrow \frac{1}{2}mv_1^2 - Wair = mgh + \frac{1}{2}mv_2^2$ (use Δh for h)