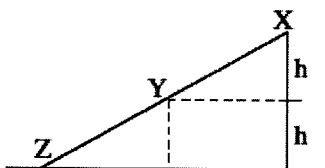# Conservation of Energy Worksheet

1. A trolley makes two separate runs down an inclined plane. It is released first from Y, halfway up the slope and then from X at the top of the slope.

Which of the following statements is/are true?

I. The trolley takes twice as long to run from X to Z as it take to run from Y to Z.
II. At Z the trolley is going twice as fast when released at X as it is when it is released at Y.
III. At Z the trolley has twice as much kinetic energy when released at X as it has when released at Y

(A) (III) only
(B) and (III) only
(C) and (II) only
(D) (I), (II) and (III)

It will have twice as much kinetic energy because the initial potential energy is twice the amount.

2. A spring-loaded toy dart gun is used to shoot a dart straight up in the air, and the dart reaches a maximum height of 24 m. The same dart is shot straight up a second time from the same gun, but this time the spring is compressed only half as far as before firing. How far up does the dart go this time, neglecting friction and assuming an ideal spring?

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

if x is only half then h, is going to change by $\left(\frac{1}{2}\right)^2$ which is $\frac{1}{4}$

(A) 24 m
(B) 17 m
(C) 12 m
(D) 6 m

3. A marble is dropped from the top of a skyscraper. The work done by the earth's gravitational force on the marble is

(A) equal to the work done by the marble's gravitational force on the earth
(B) smaller than the work done by the marble's gravitational force on the earth
(C) larger than work done by the marbles gravitational force on earth
(D) more information is needed.

the FORCE will be the same for both but the marble moves a much greater distance than the earth.

4. Compared to the amount of energy required to accelerate a car from rest to 10 miles per hour, the amount of energy required to accelerate the same car from 10 mph to 20 mph is

    $E = \frac{1}{2}mv^2$

    (A) the same.
    (B) twice as much.
    (C) three times as much.
    (D) four times as much.

    It take $4x$ the energy to go from 0 to 20 as it does 0 to 10

    therefore it takes $3x$ the energy to go from 10 to 20.

5. When a 50 kg person is hangs from a 20 m bungee cord it stretches to a length of 32m.

    (a) Calculate the spring constant of the bungee cord (assuming it obeys Hooke's law).

    $F = kx$
    $mg = kx$
    $(50kg)(9.8m/s^2) = k(32m - 20m)$

    $k = \underline{40.8 \ N/m}$

    (b) How much work is required to stretch the cord by this much?

    $W = E = \frac{1}{2}kx^2$
    $= \frac{1}{2}(40.8 \ N/m)(12m)^2$
    $= \underline{2938 \ J}$

    (c) How heavy a person is required to make the cord stretch twice as much?

    Since $F = kx$

    then if x is doubled, force must be doubled

    so a 100 kg person.

    (d) How much additional work is required to make the cord stretch twice as much?

    $W = \frac{1}{2}kx^2$
    $= \frac{1}{2}(40.8)(24m)^2 = 11750$

    $11750 - 2938 = \underline{8812 \ J}$ of additional work

6. In the sport of Bungee Jumping people stand on a high platform and allow themselves to fall while tied to the platform by an elastic cord attached to their ankles. Johanna does a bungee jump. The unstretched length of the bungee cord is 20.0 m. Johanna's center of mass is 1.0 m above her feet when she is standing and her mass is 54.0 kg. In her initial drop the lowest point she reaches is when her feet are 45.0 m below the platform (Since she is upside down while she is falling her center of mass is 47.0 m below its initial position).
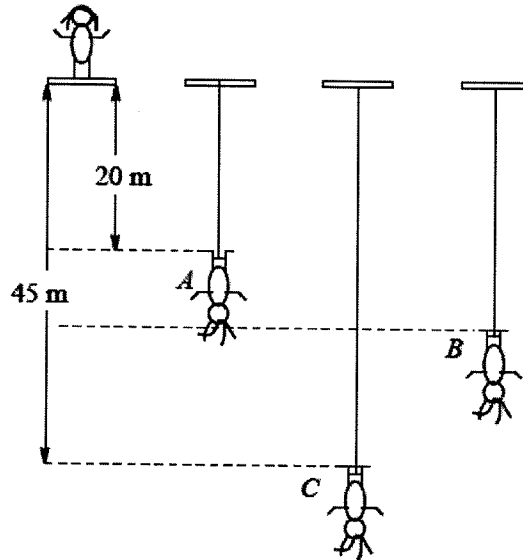
(a) As Johanna drops, describe the energy changes taking place. Do this by writing increasing, decreasing or constant under the headings gravitational potential energy, kinetic energy and elastic potential energy in the table below. The top row refers to energy changes between her initial position on the platform and position A - the point where the bungee cord just starts to stretch; the middle row as she falls from point A to point B - the final equilibrium position; and the bottom row as she falls from point B to position C the lowest point of her initial drop.

	Gravitational Potential Energy	Kinetic Energy	Elastic Potential Energy
From platform to A	decreasing	increasing	constant
From A to B	decreasing	Increasing	increasing
From B to C	decreasing	decreasing	increasing

(b) Using conservation of energy calculate Johanna's speed at point A just before the bungee starts to stretch.

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

$$(9.8 \, m/s^2)(20m) = \frac{1}{2}v^2$$

$$V = 19.8 \, m/s$$

(c) Using conservation of energy calculate how much energy is stored in the bungee cord at point C when Johanna is momentarily at rest at her lowest position?

at top = at bottom
$$E_p \qquad E_s$$

$$mgh = (54\,kg)(9.8)(47\,m) = \underline{24\,872\ J}$$

(d) Using your answer to (c) calculate the magnitude of the spring constant of the bungee (assuming it obeys Hooke's Law).

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

$$24\,872\ J = \tfrac{1}{2}k(25\,m)^2 \qquad\qquad \underline{k = 79.6\ N/m}$$

(e) Calculate the net force acting on Johanna at C and hence calculate her acceleration as she bounces back up again.

$\uparrow F_{spring}$

$\downarrow F_g$

$$F_{net} = F_{spring} - F_g$$
$$= kx - mg$$
$$= (79.6\ N/m)(25\,m) - (54\,kg)(9.8\ m/s^2)$$
$$\underline{F_{net} = 1461\ N}$$

$$F = ma$$
$$1461 = 54(a)$$
$$\underline{a = 27.1\ m/s^2}$$

(f) After bouncing up and down a number of times she loses energy and comes to rest at B hanging by her angles. By how much is the cord stretched at B.

$\uparrow F_s$

$\downarrow F_g$

at rest, $a = 0$

$$F_{spring} = F_g$$
$$kx = mg$$
$$(79.6\ N/m)\,x = (54\,kg)(9.8\,m/s^2)$$
$$\underline{x = 6.6\ m}$$

(g) What problems could arise if the spring constant of the bungee were too small or too large?

too small — the spring will stretch easier therefore it may stretch too much and the person will hit his/her head on the ground.

too large — the spring will be too hard to stretch. Thus the forces may be too large and the person could be hurt.