Conservation of energy worksheet #3
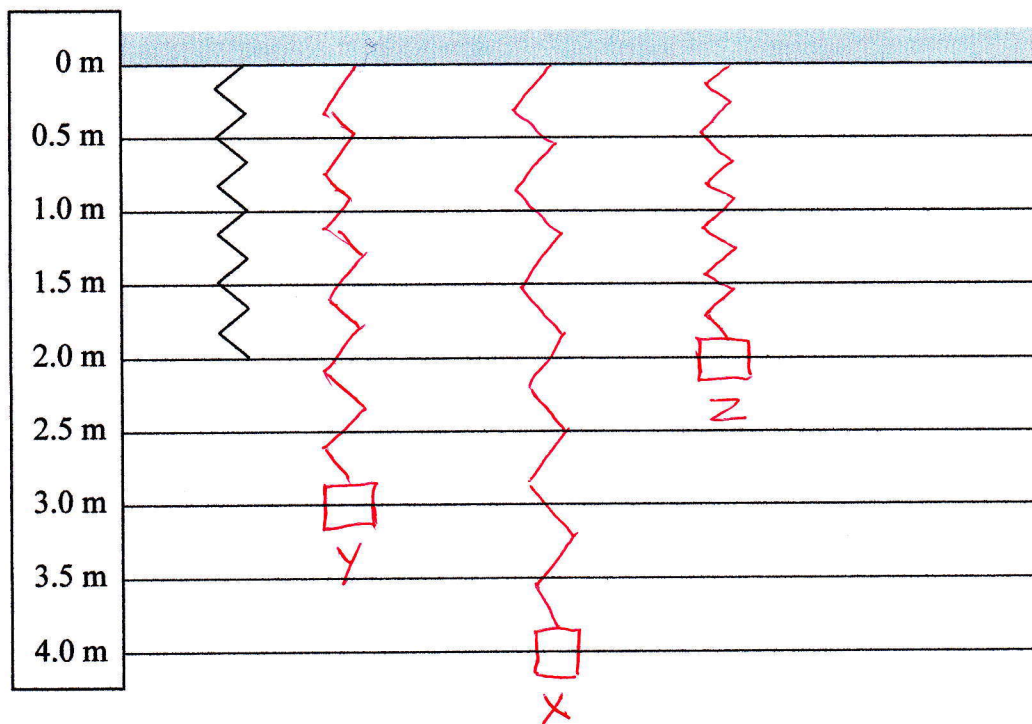(Take the value of $g = 10$ m/s^2)

Students hang a spring of unstretched length 2 m from a solid support as shown in the diagram below.

They then add a mass of 1 kg to the bottom of the spring which stretches down to a length of 3 m measured to the middle of the mass. Add this to the diagram above on the right of the unstretched spring.
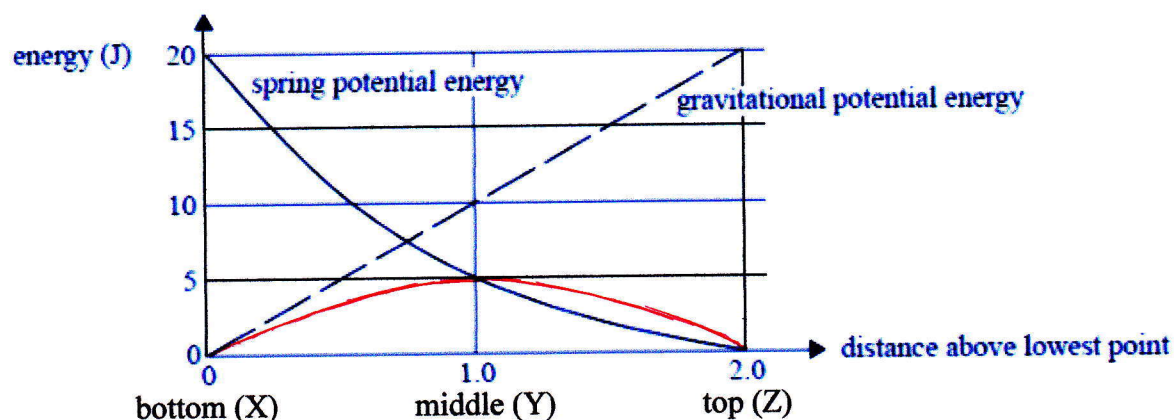
The students then pull down on the mass to a length of 4 m (measured to the middle of the mass) and release the mass. This causes the spring to oscillate between the 4 m mark (point X) to the middle point at 3 m (point Y) and up to the 2 m mark (point Z).

Add to the diagram above the position of the stretched spring and mass at the 4 m mark and the in-between position at the 3 m mark. Label the three positions you have drawn as X, Y and Z.

The zero point of GPE is taken to be point X at the 4 m mark.

1. At which position is the GPE of the oscillating spring and mass, a maximum? ___Z___

2. At which position is the KE of the oscillating spring and mass, a maximum? ___Y___

3. At which position is the spring potential energy (SPE) of the
   oscillating spring and mass a maximum? ___X___

The EPE and GPE are plotted on the graph below.

energy (J) — spring potential energy — gravitational potential energy — distance above lowest point

bottom (X)   middle (Y)   top (Z)

4. What is the total energy of the system when the mass is at the bottom point (X)? $\underline{20\,J}$

5. What is the total energy of the system when the mass is at the middle point (Y)? $\underline{20\,J}$

6. Hence, what is the kinetic energy of the mass at the middle point (Y)? $\underline{5\,J}$

7. From the data, calculate the speed of the mass at the middle point (Y).

$$KE = \tfrac{1}{2}mv^2$$
$$5 = \tfrac{1}{2} \times 1 \times v^2$$
$$v = \sqrt{10} = 3.16 \text{ m/s}$$

8. Complete the table below that shows the different energy forms for the mass at the different positions.

Position	Gravitational potential energy (GPE)	Spring potential energy (SPE)	Kinetic energy (KE)	Total energy
X	0 J	20 J	0 J	20 J
Y	10 J	5 J	5 J	20 J
Z	20 J	0 J	0 J	20 J

9. Add a sketch of the kinetic energy of the mass onto the graph at the top of this page.

(The KE graph will be curved rather than 2 straight sections between 0 & 5 J to give a total of 20 J at every position.)