On potential and kinetic energy

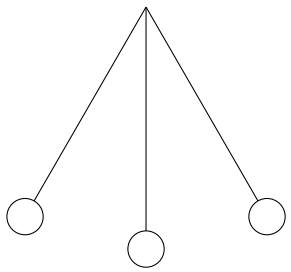
A.C. Norman
anorman@bishopheber.cheshire.sch.uk

Warm-up problems

1. Name four types of energy. What is the unit of energy, and why is it such a useful quanitity in physics?

2. Write down the formulæ which can be used to work out gravitational potential energy and kinetic energy. Make sure you write down what each of the symbols means, and what unit is usually used to measure it.

3. Draw a simple flow chart to show the energy changes that happen in each swing of a pendulum.



Regular problems

4. On 15 May 1953, Edmund Hillary climbed from the British Everest Expedtion's Camp IV at 21 200 ft to Camp VII at 24 000 ft—a climb of 853 m—twice, carrying stores and gear in order to lighten the load for the parties who were to climb the Face to the South Col. The average load carried up the Lhotse Face was 30 lb (=13.6 kg). Taking Hillary's mass as 75 kg, how much energy would he have needed for this climb?

5. A wind turbine's blades have a span diameter of 70 m. On a pretty windy day, the wind speed might go up to 8 m/s.

   (a) What is the total area of the circle swept out by the blades?

   (b) What is the volume of air which passes through this circle each second?

   (c) The density of air is about 1.3 kg/m^3. What is the mass of air passing through the blades each second.

   (d) What is the kinetic energy of this mass of air (NB this is the maximum energy you can extract from it)?

(e) The Wern Ddu wind farm near Corwen in Wales has 4 turbines of diameter 71 m. Its annual production is 23 GWh, meaning each turbine produces an average of 660 kJ of energy every second. Comment on this value.

6. Loch Sloy is a hydro-electric power scheme (completed in 1950) in a rainy place in Scotland. In fact, it gets 2900 mm of rain per year (cf. Malpas at around 600 mm). It's also rather higher up than Malpas: large areas of land are over 300 m above sea level (Malpas is at about 120 m). Loch Sloy's surface area is 1.5 km^2, and its water catchment area is about 83 km^2.

   (a) What volume of water falls on Loch Sloy's water catchment area every year?

   (b) If all that water were allowed to fall from 300 m down to sea level, how much energy would result?

   (c) The amount of electrical energy the plant produced in 2006 was 142 GWh (=5.1×10^{14} J). Compare this answer to your calculated energy and comment on this.

7. A wicked goblin has fallen down a well which is 15 m deep.

   (a) How much gravitational potential energy must the goblin gain if it is to escape from the well? (It is a well known fact that goblins have a mass of 39 kg.)

   (b) The sides of the well are very smooth and slippery, so climbing out is not an option. The goblin must try to jump out of the well. How quickly must the goblin jump upwards in order to have enough kinetic energy to be able to escape?

8. (a) Draw a series of diagrams to show what is happening during a pole vault (divide the pole vault into 5 stages: run up, going up, top of the vault, coming down, and landing).

   (b) Describe the energy changes during each stage of the pole vault.

   (c) Draw a sketch graph to show the how the vaulter's kinetic and potential energy (draw 2 separate lines) changes with time, marking on the position of the pole vaulter at significant points.

Extension problems

9. A brick is dropped from a scaffolding onto the floor. When the builder has climbed down to retrieve it, he finds it lying still on the floor. Where has all the energy gone? Explain how this happened. Could you convince the builder (and me!) that energy has been conserved?

10. It is often said that we use too much energy (sometimes there is talk of an 'energy crisis' if the energy supply cannot match up to the demand). If energy cannot be created or destroyed, how can we 'use up' energy? Why isn't it possible to keep 'using' the same energy over and over again?