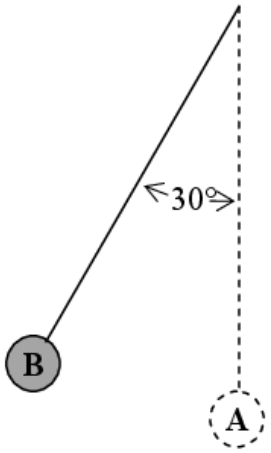
Question 1

(*a*) State the law of conservation of energy. (4)

The pendulum in the diagram is 8 m long with a small bob of mass 6 kg at its end. It is displaced through an angle of 30° from the vertical (position **A**) and is then held in position **B**, as shown. Calculate the height through which the bob has been raised and the potential energy that it has gained. (9)



The bob is then released and allowed to swing freely. What is the maximum velocity it attains? (9)

When the moving bob is at position **A**, a force is applied which brings the bob to a stop in a distance of 5 mm. Calculate the force applied. (6)

(acceleration due to gravity, $g = 9.8\ \text{m s}^{-2}$)

Question 2

11. Read the following passage and answer the accompanying questions.

Windmills have been used for thousands of years to grind grain but the first attempts to use wind turbines to generate electricity were not made until the late 1800s. Viable large scale wind turbines were not produced until the 1980s. At the moment about 12% of Ireland's electricity needs are met by wind energy and it is planned to increase this to 33% by 2020.

Wind is a source of renewable energy and is now one of the most cost-effective methods of electricity generation.

The power P of the wind can be calculated from $P = \rho A v^3$ where ρ is the density of the air, A is the area the wind acts on and v is the speed of the wind. In theory it is possible to extract 58% of this energy in a wind turbine. Much of the loss occurs as the wind is slowed down rather than stopped as it passes the turbine.

The rotating blades of the turbine transfer their energy to an a.c. generator, which produces electricity by electromagnetic induction. The resulting alternating supply has to be changed to match the 230 V, 50 Hz that is used for electrical supply in Ireland.

Many people are concerned about the noise associated with wind turbines. Better blade construction has led to reduced noise. At about 150 m from a turbine, typical sound intensity levels are 45 dB. This reduces to 42 dB at about 200 m away. These values compare favourably with values of around 60 dB in a busy office.

(Adapted from: Renewable Energy, Edited by Godfrey Boyle, Oxford University Press in association with The Open University.)

(*a*) What is the effect on the power of the wind if the wind speed is doubled?

(*b*) Why is it not possible to extract all of the energy in the wind striking a wind turbine blade?

(*c*) What is electromagnetic induction?

(*d*) How is the output voltage of a wind turbine changed to 230 V a.c.?

(*e*) Estimate the factor by which the sound intensity changes when you move from a position which is about 200 m away to a position which is about 150 m away from a typical wind turbine.

(*f*) What is the tip speed (the linear velocity of the outer end) of a blade of radius 30 m when it completes a revolution every 3 seconds?

(*g*) Small scale wind turbines are sometimes used to charge batteries.
The a.c. output voltage has to be converted to a d.c. voltage. How is this achieved?

(*h*) Name one other renewable source of energy.

(8×7)

Question 3

(*a*) State the principle of conservation of energy. (4)

In a pole-vaulting competition an athlete, whose centre of gravity is 1.1 m above the ground, sprints from rest and reaches a maximum velocity of 9.2 m s^{-1} after 3.0 seconds. He maintains this velocity for 2.0 seconds before jumping.

Draw a velocity-time graph to illustrate the athlete's horizontal motion.
Use your graph to calculate the distance travelled by the athlete before jumping. (12)

What is the maximum height above the ground that the athlete can raise his centre of gravity? (12)

(acceleration due to gravity = 9.8 m s^{-2})

Question 4

(a) State the principle of conservation of energy. (6)

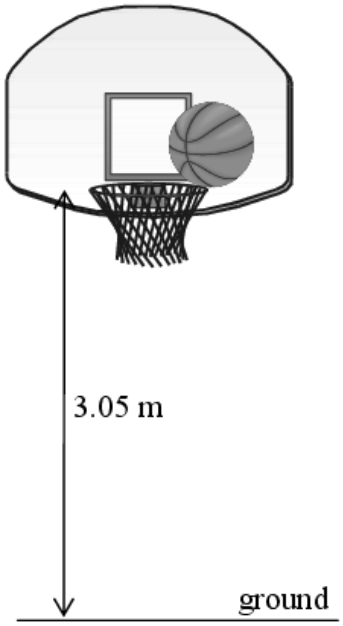
A basketball of mass 600 g which was resting on a hoop falls to the ground 3.05 m below.

What is the maximum kinetic energy of the ball as it falls? (9)

On bouncing from the ground the ball loses 6 joules of energy. What happens to the energy lost by the ball? (4)

Calculate the height of the first bounce of the ball. (9)

(acceleration due to gravity = 9.8 m s^{-2})



Question 5

(c) The average value for the solar constant in Ireland is 1.2×10^2 W m^{-2}. What is the average energy falling normally on an area of 5 m^2 of ground in Ireland in 1 minute? (7)