Question 1

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

energy is neither created nor destroyed 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.

$h = l(1 - \cos\theta)$ / $h = 8 - 8\cos 30$ / $h = 1.07$ m 3

$E = mgh$ 3

$E = 6 \times 9.8 \times 1.07 = 63$ J *(–1 for omission of or incorrect units)* 3

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

kinetic energy = 63 J *(stated or implied)* 3

$\frac{1}{2}mv^2 = 63$ J 3

$v = 4.58$ m s^{-1} *(–1 for omission of or incorrect units)* 3

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.

$W = Fd$ // $F = ma$ 3

$F = 63 \div 0.005 = 12604.3$ N // $F = 6 \times 2100.7 = 12604.3$ N 3

(–1 for omission of or incorrect units)

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

Question 2

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

power increased by a factor of 8 — 7

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

wind is slowed down — 4

rather than stopped — 3

(*c*) **What is electromagnetic induction?**

(when) a conductor/wire cuts *magnetic* flux — 4

an emf /voltage is induced — 3

(−1 if 'magnetic' not specified)

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

transformer — 7

(*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.**

increase (in level) = 3 (dB) — (4)

(sound intensity is) doubled / (increased) by a factor of 2 **(−1 if '$\frac{1}{2}$' given as answer)** — 7

(*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?**

$T = \frac{2\pi R}{v}$ — 4

$v = \frac{2\pi(30)}{3}$ / 20π / $62.8(3)$ m s^{-1} **(−1 for omission of or incorrect units)** — 3

(*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?**

diode / rectifier — 7

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

any valid answer, e.g. geothermal, solar, etc. — 7

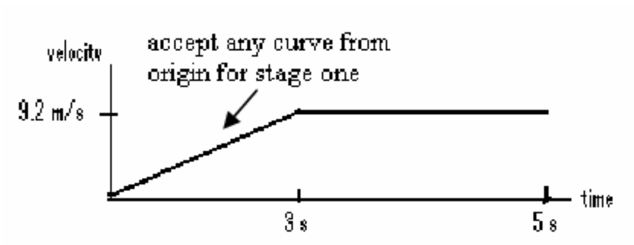
Question 3

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

energy cannot be created // total energy of an isolated system / sum of K.E + P.E — 2

nor destroyed // remains constant — 2

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.



both axes labelled — 3

two stages shown on graph — 3

Use your graph to calculate the distance travelled by the athlete before jumping.

distance (s) = area under curve // any one correct 'equation of motion' — 3

$s = \frac{1}{2}(3)(9.2) + 2(9.2)$ / 13.8+18.4 / 32.2 m // 32.2 m — 3

(–1 for omission of or incorrect units)

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

K.E. converted to P.E. (state/imply) // $|v_i| = |u_j|$ **state/imply** — 3

$h_{max} = \frac{\frac{1}{2}v^2}{g}$ // $v^2 = u^2 + 2as$ — 3

$h_{max} = \frac{\frac{1}{2}(9.2)^2}{9.8}$ // $0 = (9.2)^2 + 2(-9.8)s$ — 3

(h_{max} = 4.32 m) $\Rightarrow$ max. height = 4.32 + 1.1 = 5.42 m — 3

(–1 only, if final answer given as 4.32 m)

Question 4

Question 12 (a)

State the principle of conservation of energy. (6)

energy cannot be created or destroyed // total energy of an isolated / closed system — 3

it can be changed from one form into another // remains constant — 3

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)

(max) KE = PE (at height of 3.05 m) // $v^2 = u^2 + 2as$ / $v^2 = 0 + 2(9.8)(3.05)$ — 3

$E = mgh$ // $v^2 = 59.78$ — 3

E = 17.9(34) J // [$E_k = ½mv^2 = ½\,(0.60)(59.78)$] ➔ E_k = 17.9(34) J — 3

(-1 for omission of or incorrect unit)

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

changes into sound / heat / other forms — 4

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

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

[retained energy = E = 17.9 – 6] ➔ E = 11.9 J — 3

[$h = E / mg$] ➔ h = 11.9 / (0.600)(9.8) — 3

h = 2.02 m **accept range: (2.02 --- 2.03) m** — 3

(-1 for omission of or incorrect unit)

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)

energy per sec on 5 m^2 = $(1.2 \times 10^2)(5)$ or 600 J

// energy per minute on 1m^2 = $(1.2 \times 10^2)(60)$ or 7200 J (4)

energy per minute on 5 m^2 = $(1.2 \times 10^2)(5)(60)$ or 36,000 J or 3.60×10^4 J 7

(units not required)