WORK-ENERGY-POWER

1 An ornamental garden includes a small pond, which contains a pumped system that causes water to go up a pipe and then to run down a heap of rocks.

Fig. 3.1 shows a section through this water feature.

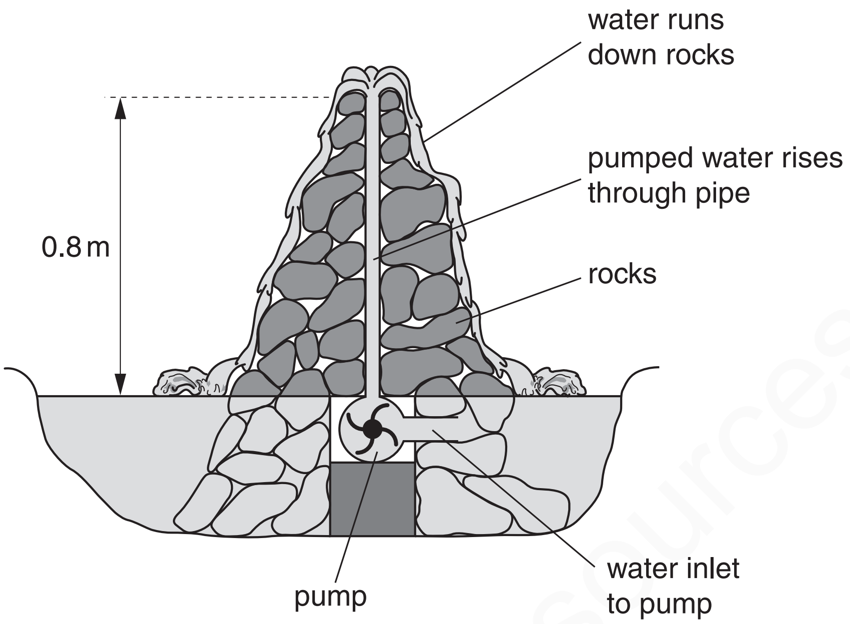

Fig. 3.1

The density of water is 1000 kg / m^3. A volume of 1 litre is equal to 0.001 m^3.

(a) Calculate the mass of 1 litre of water.

mass = ... [2]

(b) Calculate the work done raising 1 litre of water through a height of 0.8 m.

work = ... [2]

(c) The pump lifts 90 litres of water per minute.

Calculate the minimum power of the pump.

power = ... [2]

(d) The pump is switched off.

Immediately after the pump is switched off, what is the value of the water pressure at the bottom of the 0.8 m pipe, due to the water in the pipe?

pressure = ... [2]

[Total: 8]

MARKING SCHEME:

(a)	M = V × D in any form OR $10^3 \times 10^{-3}$	C1	
	1 kg	A1	
(b)	mgh OR his **(a)** × 10 × 0.8	C1	
	8 J (Nm) OR 7.85 J OR 7.84 J e.c.f. from **(a)**	A1	
(c)	P = E/t OR (his 8 × 90) / 60 e.c.f. from **(b)**	C1	
	12 W (J/s or Nm/s) OR 11.77 W OR 11.76 W	A1	
(d)	ρgh in any form, words, letters, numbers	C1	
	8000 Pa (N/m^2) OR 7850 Pa OR 7840 Pa	A1	[8]

2 Some builders decide to measure their personal power ratings using apparatus they already have on site. Fig. 2.1 shows the arrangement they use.

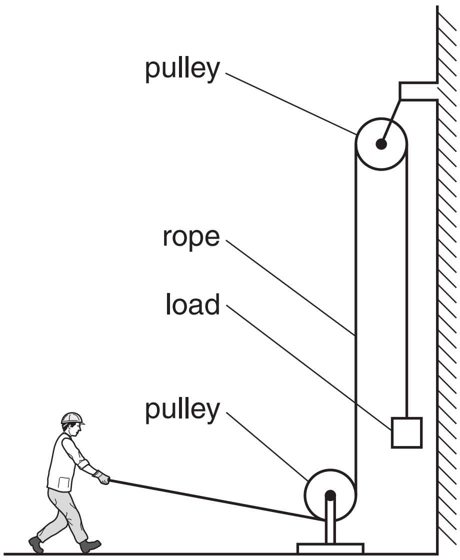

Fig. 2.1

(a) In the table below, list the three quantities they must measure in order to calculate one man's power, and the instrument they would use for each measurement.

quantity to be measured	instrument used for measurement
1.	
2.	
3.	

[3]

(b) One workman is measured as having a power of 528 W. His weight is 800 N.

He can develop the same power climbing a ladder, whose rungs are 30 cm apart.

How many rungs can he climb in 5 s?

number of rungs = ...[3]

(c) The human body is only about 15% efficient when climbing ladders.

Calculate the actual energy used from the body of the workman in **(b)** when he climbs 20 rungs.

energy used = ...[2]

[Total: 8]

MARKING SCHEME:

(a)	distance/height AND tape measure/(metre) rule(r)	B1	
	weight OR load OR force AND balance/scale(s) OR newton-meter/spring balance/force meter	B1	
	time AND watch/clock/timer	B1	
(b)	power = work/time OR energy/time in any form OR *Pt* words or numbers seen anywhere e.g. 528 x 5	C1	
	(work =) force × distance in any form	C1	
	11	A1	
(c)	efficiency = E_{out}/E_{in} OR P_{out}/P_{in} seen anywhere, clearly identified OR 520 × (20/11) × 5 OR (work done =) 800 × 20 × 0.3 OR 800 × 20 × 30 OR 4800 (J) OR 720 (J)	C1	
	(energy used =) 32,000 J	A1	[8]

3 Fig. 2.1 shows a conveyor belt transporting a package to a raised platform. The belt is driven by a motor.

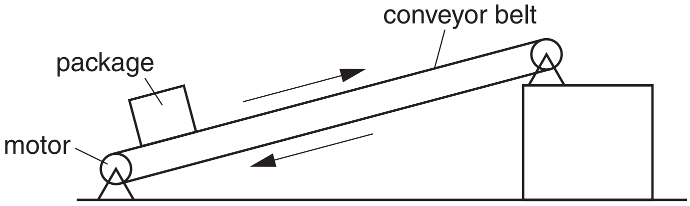

Fig. 2.1

(a) State **three** types of energy, other than gravitational potential energy, into which the electrical energy supplied to the motor is converted.

1. ....

2. ....

3. ....[2]

(b) The mass of the package is 36 kg. Calculate the increase in the gravitational potential energy (p.e.) of the package when it is raised through a vertical height of 2.4 m.

increase in p.e. = ...[2]

(c) The package is raised through the vertical height of 2.4 m in 4.4 s. Calculate the power needed to raise the package.

power = ... [2]

(d) Assume that the power available to raise packages is constant. A package of mass greater than 36 kg is raised through the same height. Suggest and explain the effect of this increase in mass on the operation of the belt.

....

....

....

....

....[3]

[Total: 9]

MARKING SCHEME:

(a)	kinetic energy (of the package / belt / motor) heat / thermal / internal energy / work done <u>against friction</u> sound energy	B2	
(b)	*mgh* OR 36 × 10 × 2.4 = 864 J OR N m	C1 A1	
(c)	*P* = *E*/*t* in any form: words, symbols or numbers OR *E*/*t* OR 864 / 4.4 = 196 W OR J / s	C1 A1	
(d)	*P* = *E*/*t* in any form, words or symbols OR mass is increased AND power is constant	B1	
	increase in <u>potential</u> energy of mass is greater OR work done / energy used (to raise mass) is greater	B1	
	speed reduced / time taken is longer	B1	[9]

4 **(a)** State an example of the conversion of chemical energy to another form of energy.

example ....

energy conversion .... [1]

(b) The electrical output of a solar panel powers a pump. The pump operates a water fountain. The output of the solar panel is 17 V and the current supplied to the pump is 0.27 A.

(i) Calculate the electrical power generated by the solar panel.

power = ... [2]

(ii) The pump converts electrical energy to kinetic energy of water with an efficiency of 35%.

Calculate the kinetic energy of the water delivered by the pump in 1 second.

kinetic energy = ... [2]

(iii) The pump propels 0.00014 m^3 of water per second. This water rises vertically as a jet. The density of water is 1000 kg/m^3.

Calculate

1. the mass of water propelled by the pump in 1 second,

mass = ... [2]

2. the maximum height of the jet of water.

maximum height = ... [2]

[Total: 9]

MARKING SCHEME:

(a) Example: e.g. battery: (chemical to) electrical
engine: (chemical to) kinetic / mechanical
fire: (chemical to) thermal / heat
(human) body: (chemical to) heat / kinetic — B1

(b) **(i)** (P =) IV OR in words OR 0.27 × 17 — C1
= 4.59 W at least 2 s.f. — A1

(ii) (K.E. =) efficiency × input OR 0.35 × 4.59 — C1
= 1.61 J or Nm at least 2 s.f. — A1

(iii) **1.** $d = m/V$ OR (m =) $V \times d$ OR in words OR 0.00014 × 1000 — C1
= 0.14 kg — A1

2. P.E. gained = K.E. lost OR $mgh = ½ mv^2$
OR 0.14 × 10 × h = 1.61 OR 1.6 — C1
h = 1.15 m OR 1.14 m at least 2 s.f. — A1

OR
$½ mv^2 = 1.61$ OR
$v^2 = 2 \times 1.61 / 0.14 = 23$ OR $v^2 = 2 \times 1.6 / 0.14 = 22.86$ — (C1)
(h =) $v^2/2g = 23/20 = 1.15$ m OR (h =) 22.86/20 = 1.14 m — (A1)

[Total: 9]

5 Fig. 3.1 shows a water turbine that is generating electricity in a small tidal energy scheme.

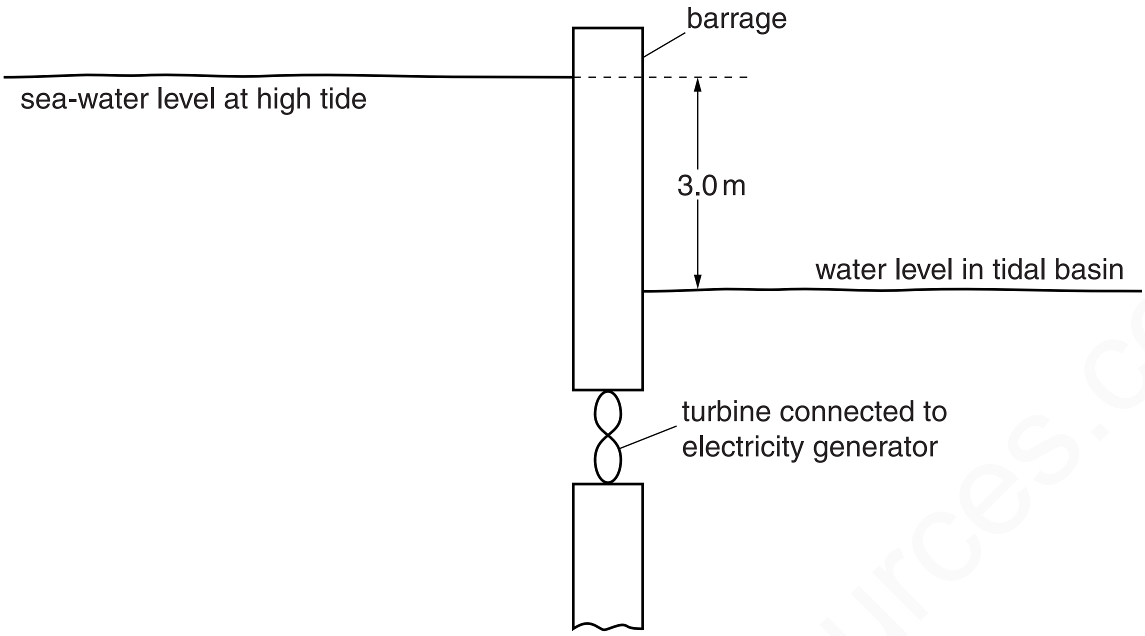

Fig. 3.1

At high tide, 1.0 m^3 of sea-water of density 1030 kg/m^3 flows through the turbine every second.

(a) Calculate the loss of gravitational potential energy when 1.0 m^3 of sea-water falls through a vertical distance of 3.0 m.

loss of gravitational potential energy = ... [3]

(b) Assume that your answer to **(a)** is the energy lost per second by the sea-water passing through the turbine at high tide. The generator delivers a current of 26 A at 400 V.

Calculate the efficiency of the scheme.

efficiency = ...% [3]

(c) At low tide, the sea-water level is lower than the water level in the tidal basin.

(i) State the direction of the flow of water through the turbine at low tide.

....

(ii) Suggest an essential feature of the turbine and generator for electricity to be generated at low tide.

....

....

....
[2]

[Total: 8]

MARKING SCHEME:

(a)	(mass flow rate =) 1030 (kg/s)	C1	
	use of *mgh*	C1	
	loss of GPE = 1030 × 10 × 3 = 30 900 J or Nm ecf from 1st line	A1	[3]
(b)	output power = (26 × 400 =) 10 400 (W)	C1	
	efficiency = output (power)/input (power) with/without 100 OR= output/input with/without 100 OR any numbers that clearly show relationship the correct way up is intended	C1	
	efficiency = (100 × 10 400/30 900 =) 33.7% at least 2 s.f. allow ecf from **(a)** and 1st line of **(b)**	A1	[3]
(c) (i)	from basin/to sea/from right/to left	B1	
(ii)	turbine design allows rotation in both directions OR meaningful comment on change of pitch OR generator works when rotating in either direction	B1	[2]

[Total: 8]

6 Fig. 3.1 shows the descent of a sky-diver from a st

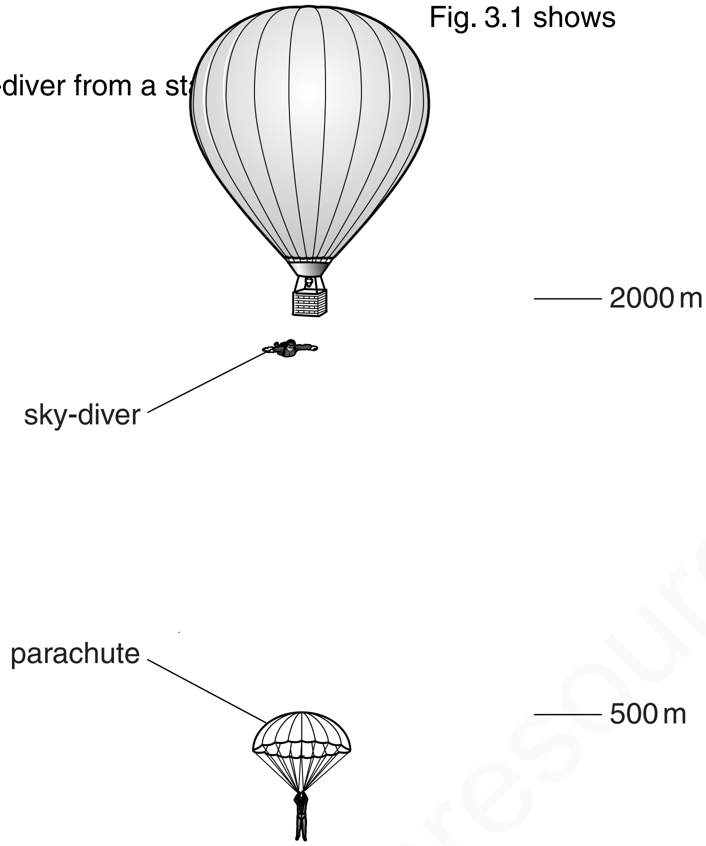

Fig. 3.1 (not to scale)

The sky-diver steps from the balloon at a height of 2000 m and accelerates downwards.

His speed is 52 m/s at a height of 500 m.

He then opens his parachute. From 400 m to ground level, he falls at constant speed.

(a) The total mass of the sky-diver and his equipment is 92 kg.

(i) Calculate, for the sky-diver,

1. the loss of gravitational potential energy in the fall from 2000 m to 500 m,

loss of gravitational potential energy = ... [2]

2. the kinetic energy at the height of 500 m.

kinetic energy = ... [2]

(ii) The kinetic energy at 500 m is not equal to the loss of gravitational potential energy. Explain why there is a difference in the values.

....

....

....[1]

(b) State

(i) what happens to the air resistance acting on the sky-diver during the fall from 2000 m to 500 m,

....[1]

(ii) the value of the air resistance during the fall from 400 m to ground.

air resistance = ...[1]

[Total: 7]

MARKING SCHEME:

(a)	**(i)**	**1.**	(loss of P.E. =) *mgh* OR $92 \times 10 \times 1500$ 1.38×10^6 J correct use of *mgh* with *h* = 500 or 2000 gains 1 mark only	C1 A1
	(ii)	**2.**	(K.E. =) ½ mv^2 OR ½ $\times 92 \times 52^2$ 1.244×10^5 J at least 2 sig. figs	C1 A1
(a)	**(ii)**		difference is due to: (work done in overcoming) air resistance/drag OR energy converted to/lost as heat (by air resistance/drag)	B1
(b)	**(i)**		increases	B1
	(ii)		920 N	B1

[Total 7]