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

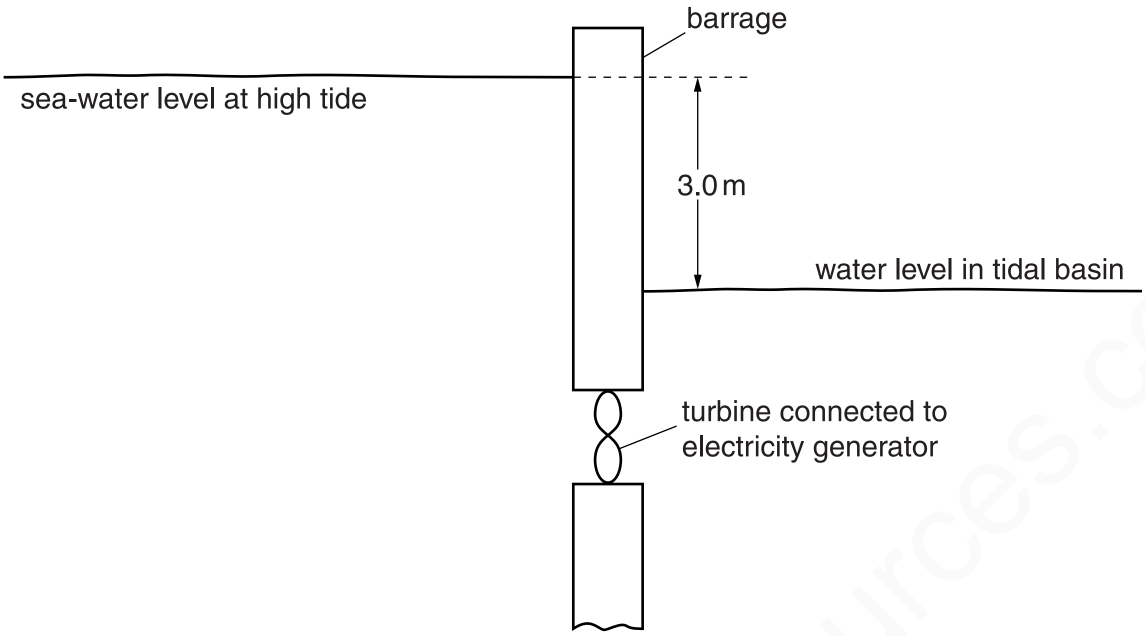

Fig. 3.1

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]

(a)	(mass flow rate =) 1030 (kg/s) use of *mgh* loss of GPE = 1030 × 10 × 3 = 30 900 J or Nm ecf from 1st line	C1 C1 A1	 [3]
(b)	output power = (26 × 400 =) 10 400 (W) 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 efficiency = (100 × 10 400/30 900 =) 33.7% at least 2 s.f. allow ecf from **(a)** and 1st line of **(b)**	C1 C1 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]

2 When a salmon swims up a river to breed, it often has to jump up waterfalls. Fig. 3.1 shows a salmon jumping above the surface of the water. On this occasion the salmon falls back down into the river.

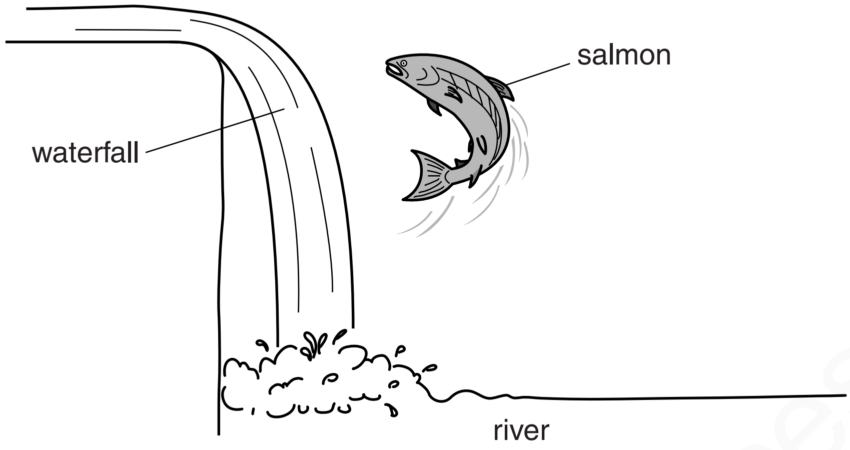

Fig. 3.1

The salmon has a mass of 2.0 kg.

(a) The salmon leaves the water vertically with a kinetic energy of 16.2 J.

(i) Calculate the speed of the salmon as it leaves the water.

speed = ... [2]

(ii) Calculate the maximum height gained by the salmon. Ignore air resistance.

gain in height = ... [3]

(iii) After the salmon has re-entered the river, it has lost nearly all its original kinetic energy.

State what has happened to the lost energy.

....

....

....

.... [2]

(b) Another salmon, of much greater mass, leaves the water vertically with the same speed.

State and explain how the height of this salmon's jump compares to the height reached by the first salmon.

....

....

.... [2]

[Total: 9]

(a)	**(i)**	$\frac{1}{2}mv^2$ in words, symbols or numbers	C1
		($v = \sqrt{(2 \times \frac{1}{2} \times 16.2)} =$) 4.0 m/s accept 4	A1
	(ii)	mgh or KE / mg or $v = \sqrt{(2gh)}$ or $v^2 = u^2 + 2as$ words, symbols or numbers	C1
		correct substitution e.g. $h = 16.2 / 2 \times 10$	C1
		0.81 m allow e.c.f. from **3(a)(i)**	A1
	(iii)	heating of <u>water</u> o.w.t.t.e. compensation mark: award B1 for one of heat, internal energy, sound, KE of water ignore intermediate states throughout **3(a)(iii)** e.g. KE / PE of splashed water	B2
(b)		same height	M1
		m affects both KE and GPE (in same way) / $v^2 = u^2 + 2as$ applies in both cases ignore "height doesn't depend on mass" special case : M1 for logical argument about not all KE becoming GPE A1 for consequent statement about height gained	A1

[Total: 9]

3 An athlete of mass 64 kg is bouncing up and down on a trampoline.

At one moment, the athlete is stationary on the stretched surface of the trampoline. Fig. 3.1 shows the athlete at this moment.

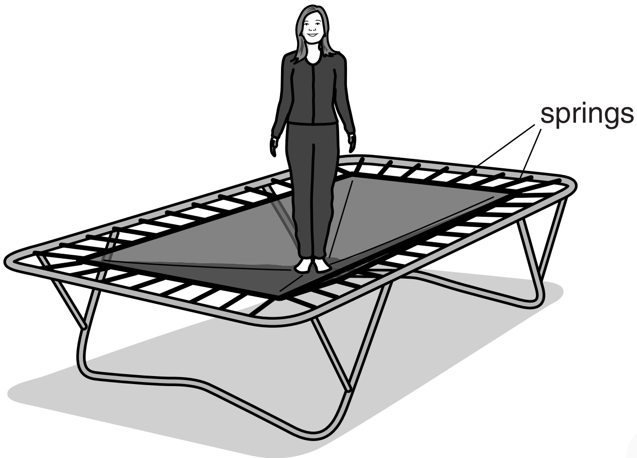

Fig. 3.1

(a) State the form of energy stored due to the stretching of the surface of the trampoline.

....[1]

(b) The stretched surface of the trampoline begins to contract. The athlete is pushed vertically upwards and she accelerates. At time *t*, when her upwards velocity is 6.0 m/s, she loses contact with the surface.

(i) Calculate her kinetic energy at time *t*.

kinetic energy = ...[2]

(ii) Calculate the maximum possible distance she can travel upwards after time *t*.

maximum distance = ...[3]

(iii) In practice, she travels upwards through a slightly smaller distance than the distance calculated in **(ii)**.

Suggest why this is so.

....

....[1]

(c) The trampoline springs are tested. An extension-load graph is plotted for one spring. Fig. 3.2 is the graph.

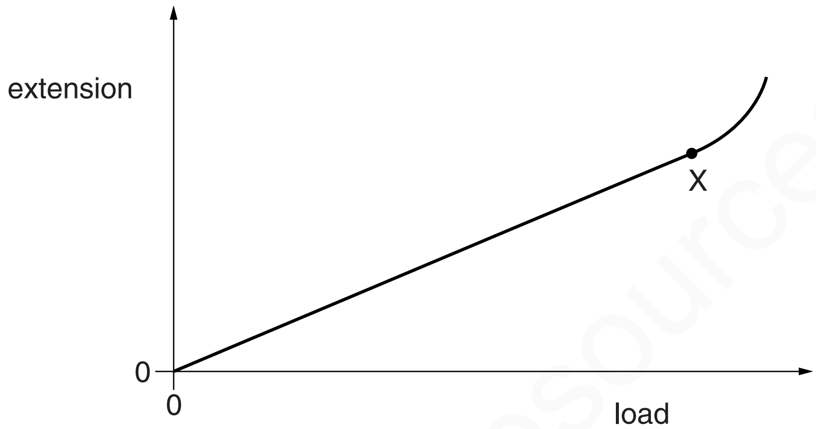

Fig. 3.2

(i) State the name of the point X.

....[1]

(ii) State the name of the law that the spring obeys between the origin of the graph and point X.

....[1]

[Total: 9]

(a)	strain / elastic (potential) (energy)	B1
(b) (i)	(KE =) ½ m v^2 in any form	C1
	1200 J	A1
(ii)	(G)PE (gained) = KE (lost) in any form	C1
	(G)PE = *mgh* OR *h* = PE ÷ *mg* in any form	C1
	1.8 m e.c.f. from **(b)(i)**	A1
(iii)	friction with air OR air resistance OR thermal energy / heat produced/lost	B1
(c) (i)	limit of proportionality	B1
(ii)	Hooke's law	B1

4 Fig. 3.1 shows water falling over a dam.

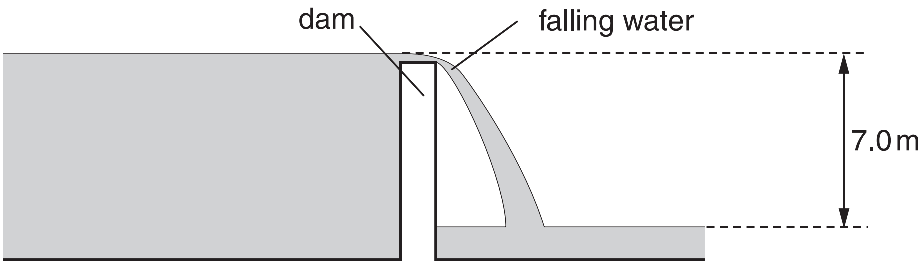

Fig. 3.1

(a) The vertical height that the water falls is 7.0 m.
Calculate the potential energy lost by 1.0 kg of water during the fall.

potential energy = ...[2]

(b) Assuming all this potential energy loss is changed to kinetic energy of the water, calculate the speed of the water, in the vertical direction, at the end of the fall.

speed = ...[3]

(c) The vertical speed of the water is less than that calculated in **(b)**. Suggest one reason for this.

....

....[1]

(a)	p.e. lost = mgh or 1 x 10 x 7	C1	
	= 70 J	A1	[2]
(b)	70 = 0.5 x m x v^2 or ecf	C1	
	v^2 = 140 or 2 x p.e.	C1	
	v = 12 m/s	A1	[3]
(c)	some p.e. changed to heat/sound/either one/work done against air resistance air/resistance acts against the motion	B1	[1]

[Total: 6]

5 Fig. 2.1 shows a track for a model car.

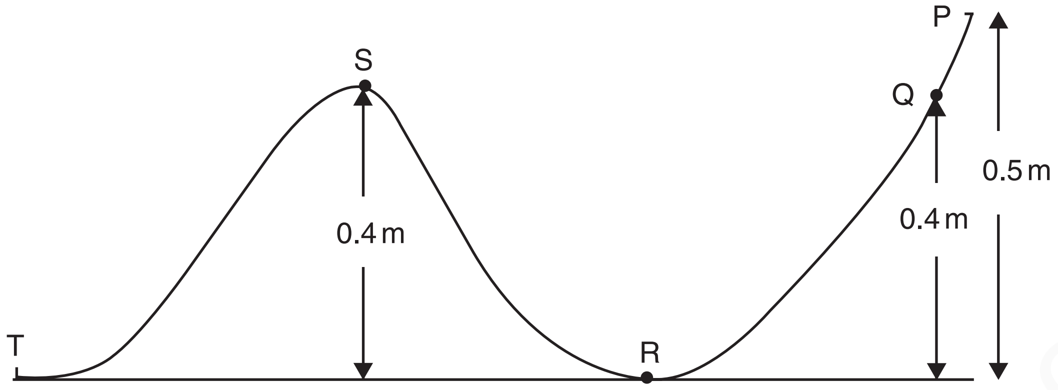

Fig. 2.1

The car has no power supply, but can run down a sloping track due to its weight.

(a) The car is released at Q. It comes to rest just before it reaches S and rolls back.

(i) Describe the motion of the car after it starts rolling back and until it eventually comes to rest.

....

....

.... [2]

(ii) Explain in terms of energy transformations why the car, starting at Q, cannot pass S.

....

....

.... [1]

(b) A second car, of mass 0.12 kg, is released from P. It continues until it runs off the track at T.

Calculate the maximum speed that the car could have at T assuming friction in the car is negligible.

speed = ... [3]

[Total: 6]

(a)	**(i)**	down to R and up towards Q/S, then reverse OR equivalent OR back towards Q, then reverse continues backward and forward until stops (at R)	 B1 B1
	(ii)	idea of energy loss OR because of friction NOT PE/KE	B1
(b)		(PE lost =) 1.2 × 0.5 OR 0.6 (J) OR 0.12 × 10 × 0.5 OR mgh OR wt × dist i.e. evidence of mgh	C1
		0.5 × 0.12 × v^2 = mgh OR 0.6 etc. e.c.f. i.e. evidence of ½mv^2	C1
		3.16 OR 3.2 m/s c.a.o.	A1

[Total: 6]

6 A farmer uses an electric pump to raise water from a river in order to fill the irrigation channels that keep the soil in his fields moist.

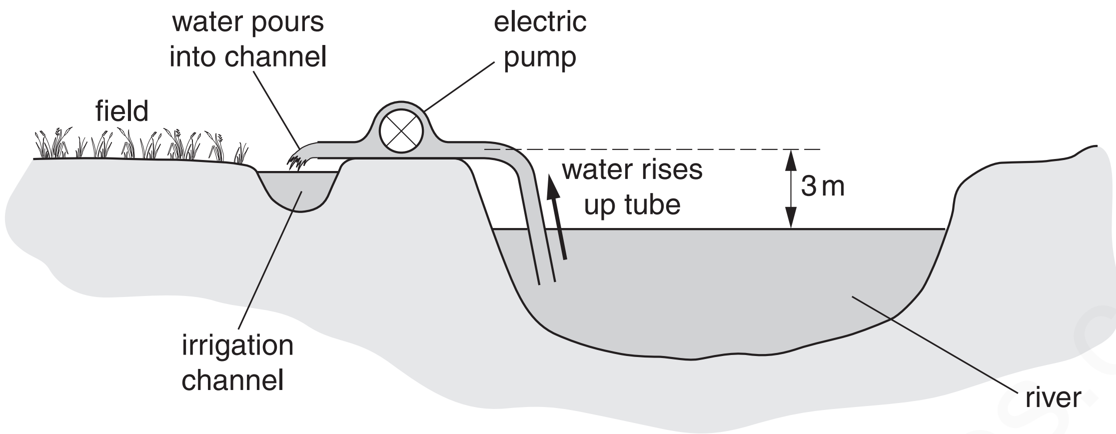

Fig. 5.1

Every minute, the pump raises 12 kg of water through a vertical height of 3 m.

(a) Calculate the increase in the gravitational potential energy of 12 kg of water when it is raised 3 m.

increase in gravitational potential energy = ... [3]

(b) Calculate the useful power output of the pump as it raises the water.

power = ... [3]

[Total: 6]

(a)	(P.E.) = mgh		C1
	12 × 10 × 3	Accept g = 9.8 or 9.81	C1
	360 J	g = 9.8 gives 352.8 J (minimum 2 s.f.) g = 9.81 gives 353.16 J (minimum 2 s.f.)	A1
(b)	(P =) E/t		C1
	360/60		C1
	6 W	352.8 J gives 5.88 W 353.16 J gives 5.886 W (minimum 2 s.f.)	A1

[6]