WORK-ENERGY-POWER

1 A wind turbine has blades, which sweep out an area of diameter 25 m.

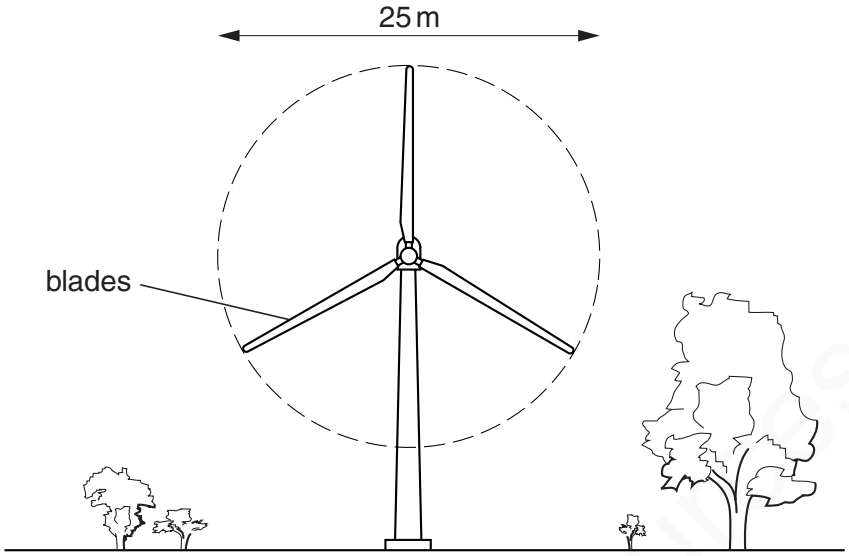

Fig. 5.1

(a) The wind is blowing directly towards the wind turbine at a speed of 12 m/s. At this wind speed, 7500 kg of air passes every second through the circular area swept out by the blades.

(i) Calculate the kinetic energy of the air travelling at 12 m/s, which passes through the circular area in 1 second.

kinetic energy = ... [3]

(ii) The turbine converts 10% of the kinetic energy of the wind to electrical energy.

Calculate the electrical power output of the turbine. State any equation that you use.

power = ... [3]

(b) On another day, the wind speed is half that in **(a)**.

(i) Calculate the mass of air passing through the circular area per second on this day.

mass = ... [1]

(ii) Calculate the power output of the wind turbine on the second day as a fraction of that on the first day.

fraction = ... [3]

[Total: 10]

(a)	**(i)**	$\frac{1}{2}mv^2$	C1	
		½ × 7500 × 12 × 12	C1	
		540 000 J OR 540 kJ	A1	
	(ii)	$W = E/t$ in any form	B1	
		10% × his **(a)**	C1	
		54 000 W OR 54 kW e.c.f.	A1	
(b)	**(i)**	3750 kg	B1	
	(ii)	[If ecf from **(i)** and no other errors, maximum mark is 2]		
		mass: ½ OR correct sub in $\frac{1}{2}mv^2$	C1	
		speed: ½ OR 6750 (J)	C1	
		fraction = ⅛ / 0.125 / 1:8 ? 12.5 % (c.a.o.)	A1	[10]

2 Fig. 1.1 shows a car on a roller-coaster ride.

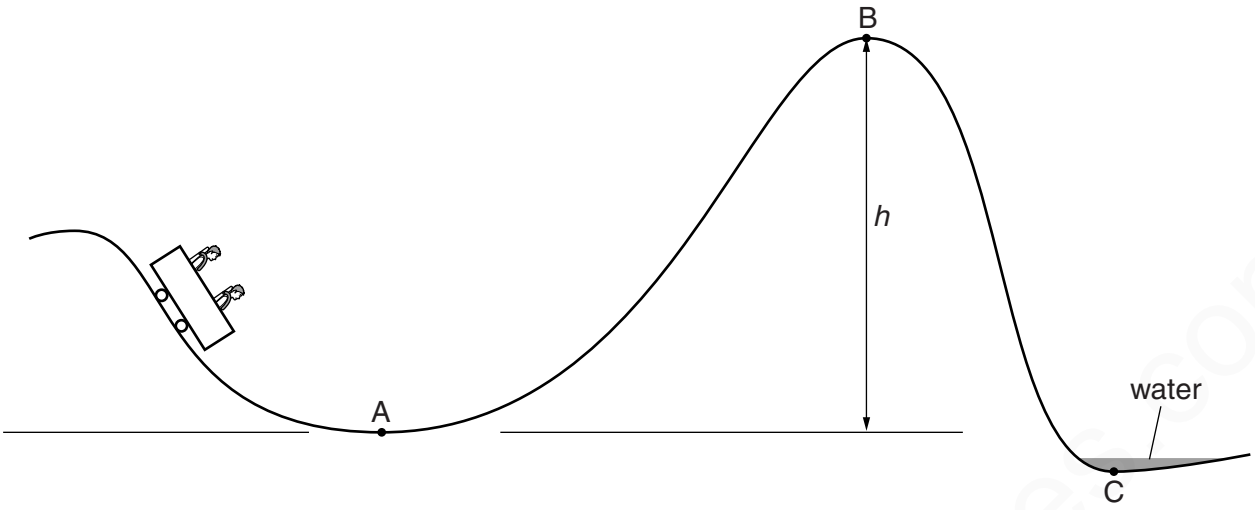

Fig. 1.1

mass of car = 600 kg
kinetic energy of car at point A = 160 kJ

(a) Calculate the speed of the car at A.

speed = ... [3]

(b) As the car travels from A to B, it loses 40 kJ of energy due to friction.

The car just manages to roll over the crest of the hill at B.

Calculate the height *h*.

height *h* = ... [2]

(c) At C, the car is slowed down by a shallow tank of water and the kinetic energy of the car is reduced to zero.

Make **three** suggestions for what happens to this kinetic energy.

1. .....

2. .....

3. .....

[Total: 8]

(a)	$\frac{1}{2} mv^2$		C1	
	correct rearrangement to find v/v^2		C1	
	23 m/s		A1	[3]
	bald 0.73 scores first two marks			
(b)	use of mgh	(= 160 000 – 40 000 = 120 000 J)	C1	
	h = 20 m		A1	[2]
(c)	any three points from:			
	KE of water			
	PE of water			
	sound			
	heat/friction			
	Award one mark for each correct point		B3	[3]

3 **(a)** **(i)** Define *power*.

.....[1]

(ii) In the following list, tick the **two** boxes next to the two quantities needed to calculate the work done on an object.

- ☐ mass of the object
- ☐ force acting on the object
- ☐ speed of the object
- ☐ acceleration of the object
- ☐ distance moved by the object [1]

(b) A lift (elevator) in a high building transports 12 passengers, each of mass 65 kg, through a vertical height of 150 m in a time of 64 s.

(i) Calculate the power needed to transport the passengers through this height.

power = ...[4]

(ii) The lift (elevator) is driven by an electric motor.

State a reason, other than friction, why the power supplied by the motor is greater than the power needed to transport the passengers.

.....

.....[1]

[Total: 7]

(a) (i) (power =) work (done) / time (taken) OR energy (supplied) / time (taken) OR rate of doing work OR rate of supplying energy B1

(ii) box 2 (force acting on the object) AND box 5 (distance moved by the object) B1

(b) (i) multiplies mass of <u>all passengers</u> by h C1
(increase in gpe =) mgh OR uses $12 \times 650 \times 150$ C1
(power = increase in) gpe / time C1
1.8×10^4 W OR 18 kW A1

(ii) energy to raise the lift OR weight / load / mass of lift OR more weight / load / mass B1

[Total: 7]

4 Fig. 1.1 shows a smooth metal block about to slide down BD, along DE and up EF. BD and DE are friction-free surfaces, but EF is rough. The block stops at F.

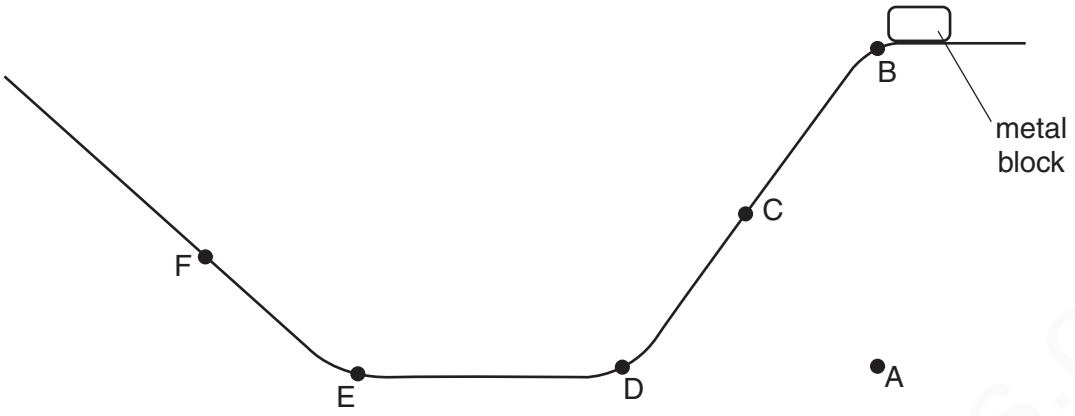

Fig. 1.1

(a) On Fig. 1.2, sketch the speed-time graph for the journey from B to F. Label D, E and F on your graph. [3]

Fig. 1.2

(b) The mass of the block is 0.2 kg. The vertical height of B above A is 0.6 m. The acceleration due to gravity is 10 m/s^2.

(i) Calculate the work done in lifting the block from A to B.

work done = ...

(ii) At C, the block is moving at a speed of 2.5 m/s. Calculate its kinetic energy at C.

kinetic energy = ...
[5]

(c) As it passes D, the speed of the block remains almost constant but the velocity changes. Using the terms *vector* and *scalar*, explain this statement.

.....

.....

.....[2]

(d) F is the point where the kinetic energy of the block is zero. In terms of energy changes, explain why F is lower than B.

.....

.....

.....

.....[3]

1 a	BD correct, (straight line i.e. constant acceleration)		B1	
	DE correct, (constant speed or slightly reducing speed only)		B1	
	EF correct, (speed reduced to zero, gradient steeper than BD)	3	B1	3
b(i)	force = 2 (N)		C1	
	work = (2 x 0.6) = 1.2 J*	2	A1	
(ii)	k.e. = $0.5mv^2$		C1	
	= 0.5 x 0.2 x 2.5 x2.5		C1	
	= 0.625 J*	3	A1	5
c	velocity - vector, speed scalar		B1	
	direction changes so velocity changes	2	B1	2
d	work done against friction		B1	
	(more) friction on EF		B1	
	(k)e. changed to heat		B1	
	less k.e. changed to p.e.	3	B1	M3*
			QT	13

5 Fig. 2.1 shows a rock that is falling from the top of a cliff into the river below.

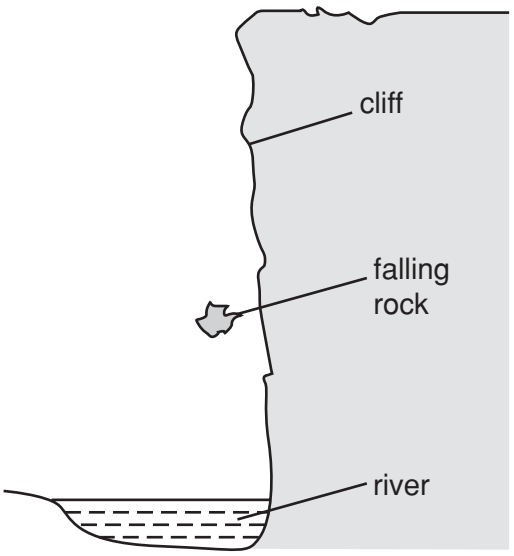

Fig. 2.1

(a) The mass of the rock is 75 kg. The acceleration of free fall is 10 m/s^2.
Calculate the weight of the rock.

weight = ……[1]

(b) The rock falls from rest through a distance of 15 m before it hits the water.
Calculate its kinetic energy just before hitting the water. Show your working.

kinetic energy = ……[3]

(c) The rock hits the water. Suggest what happens to the kinetic energy of the rock during the impact.

.....

.....

.....[3]

(a)	750 N	**A1**	**1**
(b)	p.e. lost / converted = mgh or weight x height	**C1**	
	750 x 15 or 75 x10 x15 = 11250 (J)	**C1**	
	p.e. lost = k.e. gained = 11250 (J)	**A1**	**3**
(c)	Any 3 of: heat in water / rock (kinetic) energy of (moved) water / to make water move/ make waves some k.e. still in (sinking) rock sound energy on impact / of splash	**B3**	**3**
	(just heat and sound **C1**)		

6 A group of students attempts to find out how much power each student can generate. The students work in pairs in order to find the time taken for each student to run up a flight of stairs.
The stairs used are shown in Fig. 1.1.

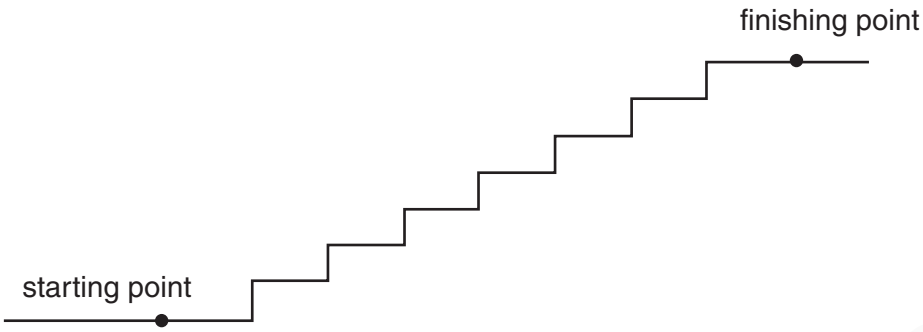

Fig. 1.1

(a) Make a list of all the readings that would be needed. Where possible, indicate how the accuracy of the readings could be improved.

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.....

.....

..... [4]

(b) Using words, not symbols, write down all equations that would be needed to work out the power of a student.

.....

.....

..... [2]

(c) **(i)** When the student has reached the finishing point and is standing at the top of the stairs, what form of energy has increased to its maximum?

.....

(ii) Suggest why the total power of the student is greater than the power calculated by this method.

.....

.....
[3]

a	height of stairs/number and height of each stair	B1	
	time	B1	
	weight/mass (x g)	B1	
	any attempt at repeat and average for time only	B1	4
b	work = force or weight x distance	B1	
	power = work/time	B1	2
c(i)	potential	B1	
(ii)	any 2: kinetic energy (to move)/heat(and sound)/energy to move arms etc	B2	3
		QT	9