O Level Pure Physics Structured

Forces Test 1.0

Q1

A 5.0 kg box is stationary on a rough horizontal surface. A constant horizontal force F is then applied to it. Fig. 10.1 shows a graph of the variation of F applied with time. The box moves with an acceleration of 0.20 m/s^2 in the first 10 s.

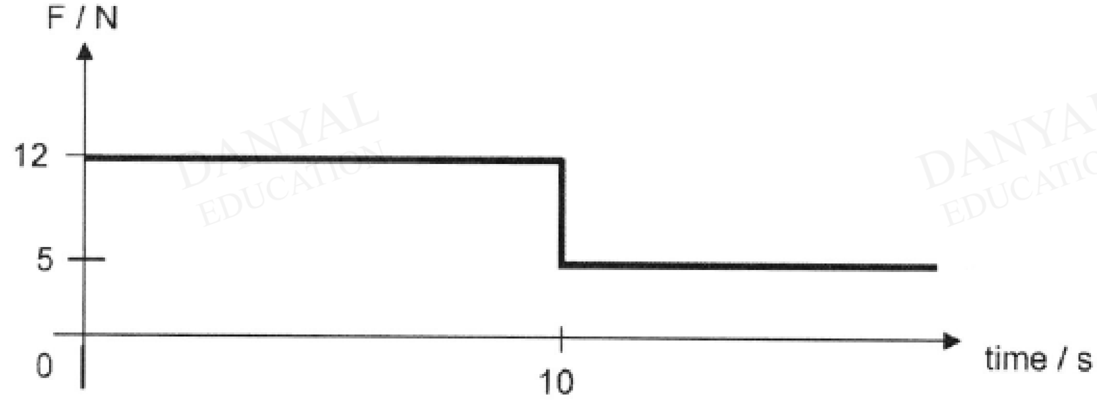

Fig. 10.1

(a) Calculate the speed of the object when the time is at 10 s. [2]

(b) Hence, calculate the distance travelled by the box in the first 10 s. [2]

(c) Calculate the frictional force between the surfaces. Assume that air resistance is negligible. [2]

(d) From 10 s onwards, the box is being pulled on a smooth surface. State the change to its acceleration, if any, and explain your answer. [2]

(e) In the presence of air resistance, how would the acceleration change in the first 10 s. Explain this change in terms of the forces acting on the box. [2]

Q2

Fig. 10.1 shows a space rocket being launch from a lunch pad at sea level. The space rocket has rocket boosters and main engines that helped the shutter to blast off from the Earth. It is said that a rocket must reach a breaking speed in order to escape from Earth. Fig. 10.2 shows information on the data about the launch. In the space after the rocket escapes, the rocket exhaust is propelling the rocket forward

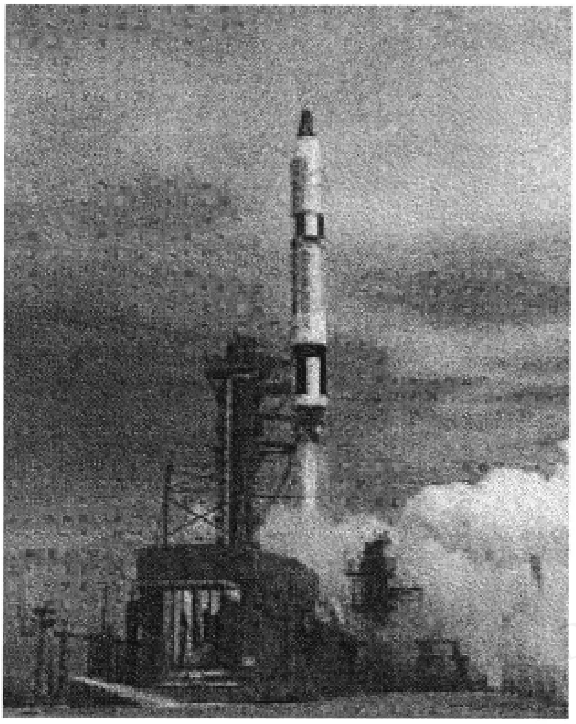

Fig. 10.1

Altitude (height) of the rocket at the escape speed just before it hit the outer space (assuming uniform acceleration)	825 000 m
Mass of space shuttle	22 700 kg
Breaking speed	11 000 m/s

Fig. 10.2

(a) Assumptions:
1) the mass of the space rocket is the same throughout the launch.
2) uniform acceleration

(i) Determine the time taken for the rocket to reach breaking speed. **[2]**

(ii) Determine the vertical acceleration of the rocket. **[2]**

(iii) Calculate the upward thrust of the rocket. **[2]**

(b) “In the space after the rocket escapes, the rocket exhaust is propelling the rocket forward. “ Explain, using the concept of forces, what this sentence means. **[2]**

(c) In reality, during launching, the space rocket will burn solid fuel that is inside the fuel compartment. Once the compartment is empty, the compartment will be detached from the main body. State how this affects the acceleration and the velocity of the rocket. **[2]**

Q3

Fig.1.1 shows a motorcycle during a race.

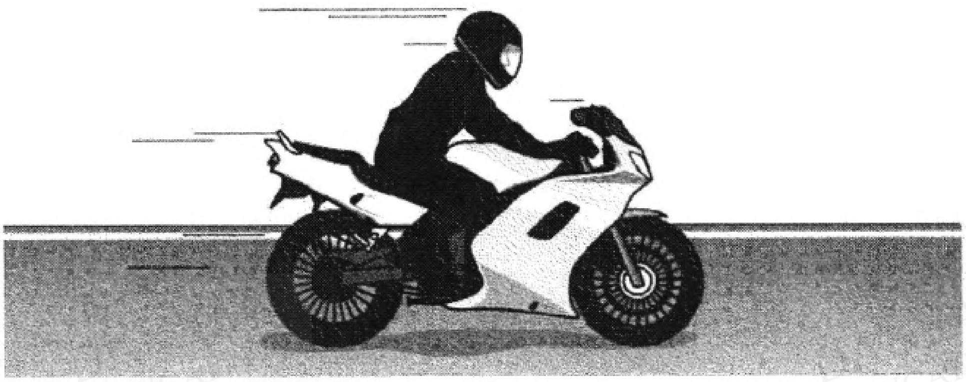

Fig.1.1

The motorcycle accelerates along a straight section of the track from a speed of 40 m/s to maximum speed.

Fig.1.2 is the speed-time graph for the motorcycle along the straight section of the track.

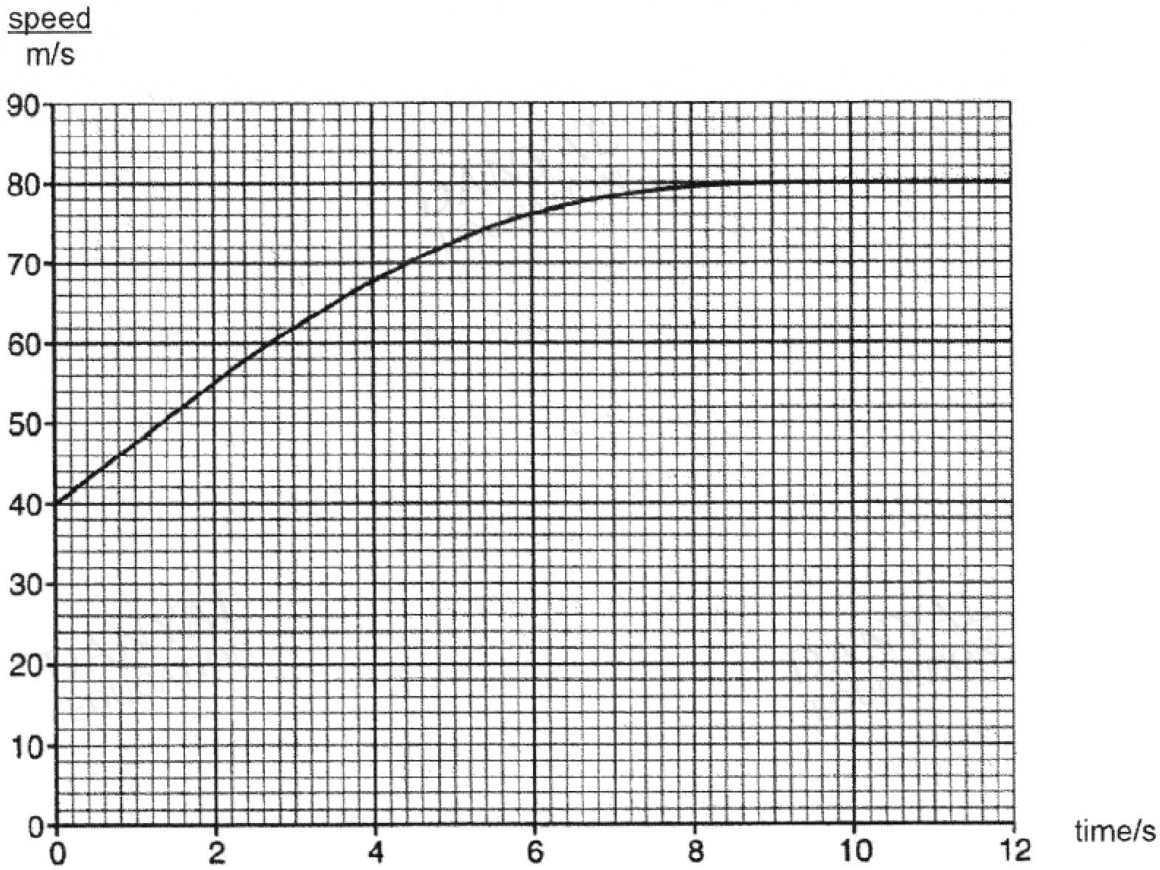

Fig. 1.2

The mass of the motorcycle is 180 kg.

(a) For the time 0 to 2.0 s, determine

(i) the acceleration of the motorcycle,

acceleration = ... [2]

(ii) the resultant force acting on the motorcycle.

force = ... [2]

(b) The driving force acting on the motorcycle remains constant throughout the 12 s spent on the straight section of the track.

(i) Using **Fig. 1.2**, state how the acceleration of the motorcycle changes during this time.

....

....

....[1]

(ii) Explain, in terms of the forces acting, why the acceleration changes in this way.

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....[3]

Q4

Some information is given below from the manufacturer of an electric car for use in a town.

	Car A with a load of 80 kg	Car B with a load of 160 kg
maximum speed	10.9 m/s	10.9 m/s
Initial acceleration	2.00 m/s^2	1.85 m/s^2

Mass of car without any load	900 kg
Furthest distance travelled by car at maximum speed without recharging	49 km
Average power produced by battery at maximum speed	4.24 kW
e.m.f. of battery	48 V
Maximum charging current	95 A

(a) **(i)** When the load in the car doubles from 80 kg to 160 kg, the initial acceleration of the car decreases slightly. Explain why the acceleration decreases but does not decrease by half.

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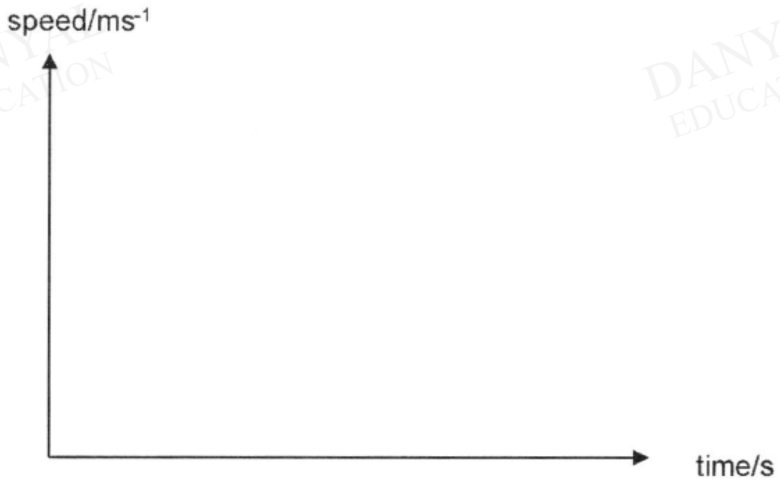
....[2]

(ii) Draw a sketch to show the motions of car A and car B in the axes given below. In your sketch, label the lines representing car A and car B and mark out any important values on the axes to represent the motion. [2]



(b) The car travels the furthest distance at the maximum speed without recharging.

Calculate

(i) the time taken,

time = ... [1]

(ii) the energy provided by the battery,

energy = ... [1]

(iii) the minimum time taken to fully recharge the battery,

time =................................... [2]

(iv) State **one** assumption that you made in calculating **(iii)**.

....

....

....

....[1]

(c) Suggest **one** environmental advantage of using an electric car in a town.

....

....

....[1]

Q5

Fig. 1.1 shows an acrobat walking a tight rope.

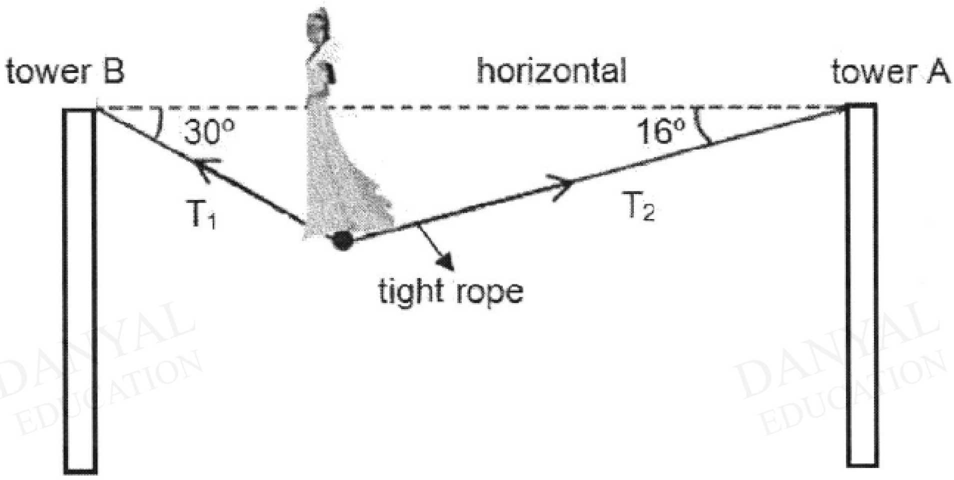


Fig. 1.1

The acrobat is at rest at the position shown in Fig. 1.1.
The tensions T_1 and T_2 in the rope are 600 N and 540 N respectively.

A second acrobat of mass 65 kg stationed at tower B jumps vertically upwards with a force of 2000 N.

The gravitational field strength is 10 N/kg.

(i) Calculate the initial acceleration of the second acrobat.

acceleration = ...[2]

(ii) On Fig. 1.2, sketch a velocity-time graph of the second acrobat from the instant she jumped upwards to the instant she lands back on tower B.

Neglect air resistance in your sketch.

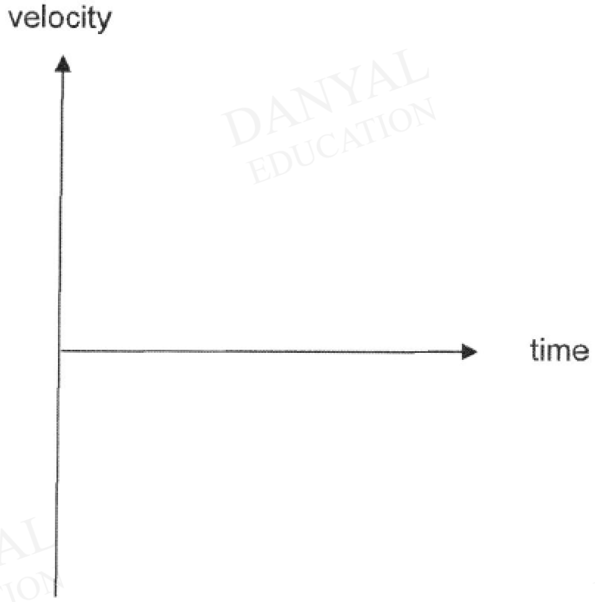


Fig 1.2

[1]

Answers

Forces Test 1.0

Q1

(a)	$a = (v-u) / t$ $0.20 = (v - 0) / 10$ $v = 2.0$ m/s	 [1] [1]
(b)	Distance = area under graph = ½ x 2.0 x 10 = 10 m	 [1] [1]
(c)	$F_r = F$ – friction m x a = 12 – friction 5.0 x 0.20 = 12 - friction friction = 11 N	 [1] [1]
(d)	The box's acceleration increases. Since F-f=ma, 5.0 – 0 = 5.0a, a =1.0 m/s².	[1] [1]
(e)	As the object moves faster, the amount of air resistance acting on it increases. This will cause the resultant force F_R on the object to decrease. Since $F_R = m \times a$, the acceleration will decrease as well.	 [1] [1]

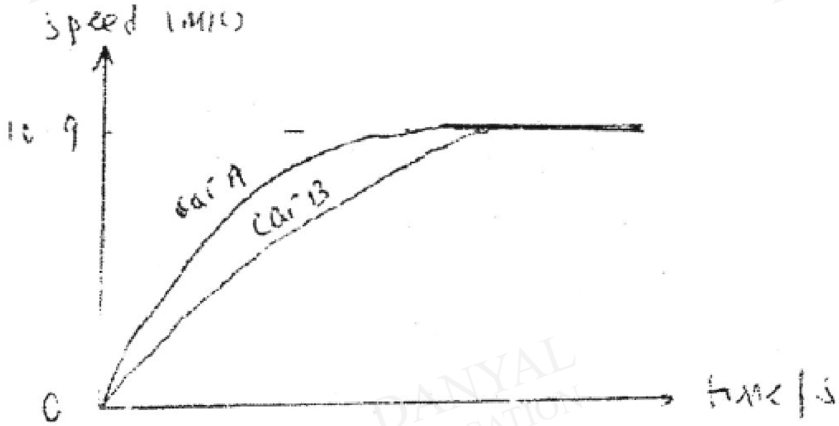
Q2

(a)(i)	>Distance under v-t = 0.5 x 11000 x t 825 000 = 0.5 x 11000 x t >t = 150 s or s=[(u+v)/2]t 825 000 =[(0 + 11 000)/2]t t= 150 s or Fd=KE + GPE = ½mv² + mgh F=[0.5 x 22 700 x 11 000 x 11 000 + 22 700 x 10 x 825 000] / 825 000 F =15.60625 x 10¹¹/ 825 000 = 1 891 666.667 a = F/m = 1 891 666.667 / 22 700 = 83.333 t = (v – u) / a = (11 000 – 0) / 83.33 = 132 s	M1 A1
(ii)	a = (v-u) / t = (11 000 – 0) / 150 = 73.3 m/s	M1 A1 (allow ecf)
(iii)	Resultant force = m a Upward thrust – W = ma Upward thrust = W + mA = (22 700 x10) + (22700 x 73.3) = 1890910 N = 1.89 x 10 ⁶ N	M1 A1 (allow ecf)
(b)	>The rocket is exerting a force on the rocket exhaust in a backward direction. From Newton's third law, the exhaust gases is exerting a force on the rocket in the forward direction. >In space with no resistive force, the force of exhaust gases on the rocket is the net force which causes acceleration in the forward direction in accordance to Newton's second law. Note: No marks are given when using N1L to explain as it is not answering the question.	B1 B1
(c)	Assuming the breakup of the fuel compartment is in space which has no air resistance and the main engine thrust remains constant, the total mass of the rocket decreases and from N2L, F=ma, the acceleration will increases and consequently its velocity as a=(v-u)/t OR Assuming the breakup of the fuel compartment is in space which has no air resistance and there is no more fuel in the rocket, the engine thrust becomes zero and from N2L, acceleration becomes zero and the velocity of the rocket remains constant. OR Assuming the breakup of the fuel compartment is in the atmosphere which has air resistance. When there is no more fuel in the rocker, the engine thrust becomes zero and from N2L, acceleration and velocity decreases due to the net opposing force of its weight and air resistance.	B1 B1

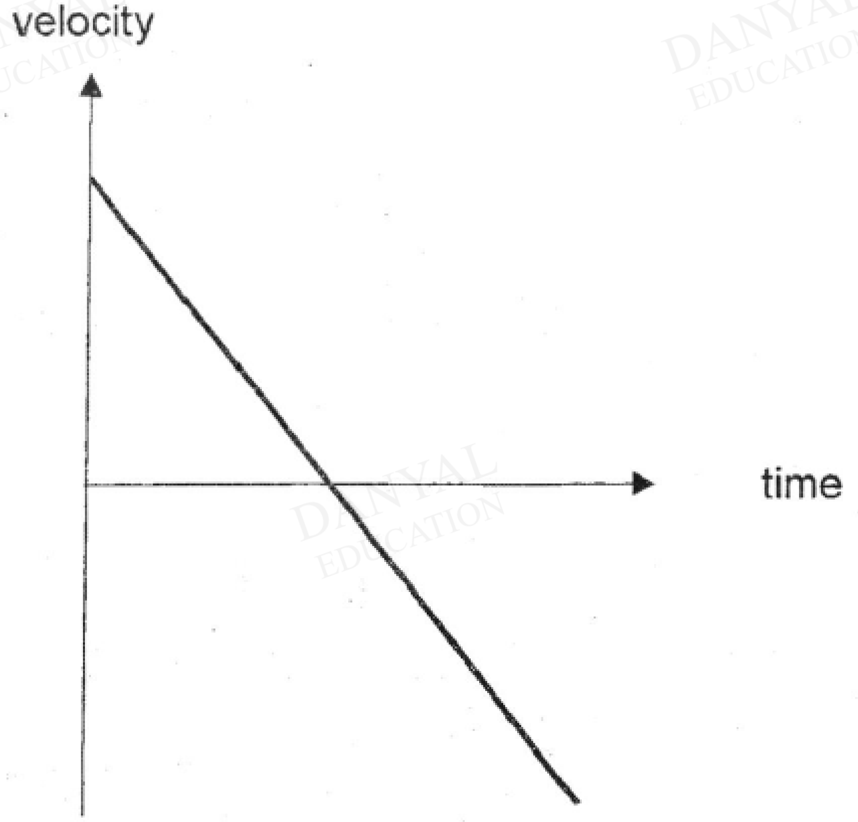
Q3

1(a)(i)	(a) =(v-u)/t or Δv/t or (55–40) /2 or equivalent values from graph = $7.5 m/s^2$	[1] [1]
1(a)(ii) **Markers Comments (MC)**	(F) = ma = 180 kg x $7.5 m/s^2$ = 1350 N Q1(a) is very well-done. Majority of the students obtained full marks.	[1] [1]
1(b)(i) **MC**	acceleration decreases to zero. OR Some students break down the acceleration into 3 parts (i) 0 to 2.0s - constant acceleration (ii) 2.0 s to 8.0 s - decreasing acceleration (iii) 8.0 s to 12.0 s - zero acceleration Many students wrote **wrongly** that the acceleration is increasing at a decreasing rate. It **should be** called decreasing acceleration.	[1] Or [1] if all parts are correct. [1/2] if only 2 parts are correct
1(b)(ii) **MC**	air resistance/friction/drag mentioned air resistance/friction/drag increases (with speed) or resultant force decrease (with speed) finally, air resistance = driving force or resultant force is zero. Some students that that the resultant force decreases without explaining that the friction force increases with speed. Some students state that at the maximum speed, the resultant is zero without explaining that at that point the air resistance is equal to the driving force. Hence no credit were given.	[1] [1] [1]

Q4

(a)(i)	Assuming that the resultant force on the car is constant, then by Newton's 2nd law, the resultant force F is equal to the total mass of the car and its acceleration a. If the total mass of the car increases by two times, then we will expect the acceleration to decrease by half. However when the load is doubled, the total mass of the car increase by a factor of (900 + 160)/ (900 + 80) = 1.08 and not a factor of 2.	[1] [1]
MC	Many students did not obtained any credits for this question as their answers did not relate to Newton's 2nd Law.	
(a)(ii)		Correct label Car A [1/2] Car B [1/2] Correct Data 10.9 [1/2] 0 [1/2]
MC	Many of the students drew straight line instead of curve line for car A and B. Many students also forgot to label the lines to show which is car A and car B.	
(b)(i)	speed = distance travelled / time taken time taken = 49 000 / 10.9 = 4490 s (3 s.f.)	[1]
(b)(ii)	energy provided by the battery = Power produced x time = $(4.24 \times 10^3) \times 4495$ = 1.91×10^7 J (3 sf)	[1]
(b)(iii)	energy needed to recharge battery = current x e.m.f. x time 1.91×10^7 J = 95 A x 48 V x time(t) Hence minimum time taken to fully charge the battery, t = $(1.91 \times 10^7)/(95 \times 48)$ = 4200 s (2 s.f.)	[1] [1]
(b)(iv)	No energy, such as heat, was lost to the surroundings during the charging of the battery.	[1]
(c)	Electric cars do not emit polluting gases, unlike fuel cars that burn petroleum for energy.	[1]

Q5

aii	weight = 405 N (accept 430 to 470 N)	B1
bi	F = ma 2000 – mg = ma 2000 – 65 x 10 = 65 a a = 20.8 m/s²	 M1 A1
bii		B1