Question Number	Acceptable Answers	Mark
1(a)(i)	Energy = power × time **Or** power = $\frac{\text{energy}}{\text{time}}$ **Or** see 4.2 × 0.4 **(1)** Energy = 1.7 (J) **(1)** <u>Example of calculation</u> Energy = 4.2 W × 0.4 s Energy = 1.68 (J)	**2**

Question Number	Acceptable Answers	Mark
1(a)(ii)	Use of $E_k = \frac{1}{2} mv^2$ **(1)** v = 5.9 / 6.0 ms^{-1} (ecf) **(1)** <u>Example of calculation</u> $v = \sqrt{\frac{2 \times 1.68\ \text{J}}{0.095\ \text{kg}}}$ $v = 5.9\ \text{m s}^{-1}$	**2**

Question Number	Acceptable Answers	Mark
1(a)(iii)	Energy is dissipated to heat **Or** work is done against friction **Or** not all the energy becomes kinetic energy **Or** air resistance on car **Or** friction between car/wheels/pin and track **Or** resistance in motor **(1)**	**1**

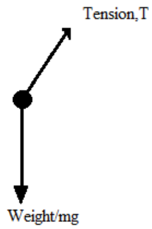
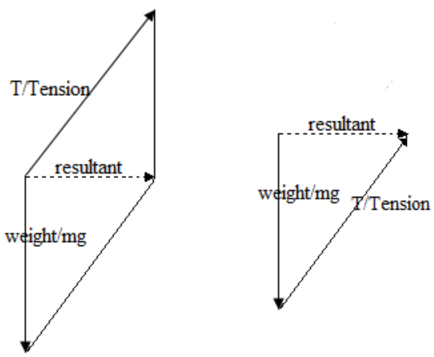
Question Number	Acceptable Answers	Mark
1(b)	No resultant force is acting on the car **(1)** (do not credit use of external force) (Car) continues moving: in a straight line **Or** in same direction **Or** with same velocity. **(1)**	**2**
	Total for question	**7**

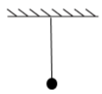
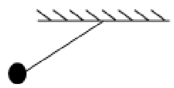
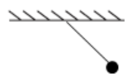
Question Number	Answer		Mark
2(a)	The balloon has the maximum/great**est** speed/velocity **Or** the great**est** distance is covered in the shortest/same time	**(1)**	**1**
2(b)	Use of $\Delta E_{grav} = mg\Delta h$ (with a Δh and not just h) Use of average rate of energy transfer = $\frac{\text{energy}}{0.15\text{ s}}$ (do not penalise power of ten errors for MP2) Average rate of energy transfer = 0.18 – 0.19(W) <u>Example of calculation</u> $\Delta E_{grav} = 0.004\text{ kg} \times 9.81\text{ N kg}^{-1} \times (1.8\text{ m} - 1.1\text{ m}) = 0.027\text{ J}$ Average rate of energy transfer = $\frac{0.027\text{ J}}{0.15\text{ s}} = 0.18\text{ W}$	**(1)** **(1)** **(1)**	**3**
	Total for question		**4**

Question Number	Answer		Mark
3(a)	Force × distance moved in the <u>direction</u> of the (applied) force (An equation with defined terms and the direction stated of the distance can score this mark)	**(1)**	**1**
3(b)	Use of KE = $\frac{1}{2}mv^2$ (with any velocity in m s^{-1}) Use of Work done = Fd (with any energy) d= 85 m **Or** Use of $F = ma$ to find the acceleration Use of suitable equation(s) of motion to find the braking distance d= 85 m <u>Example of calculation</u> $KE_{before} = \frac{1}{2} \times 1.5 \times 10^3\text{ kg} \times (24.6\text{ m s}^{-1})^2 = 4.54 \times 10^5\text{ J}$ $KE_{after} = \frac{1}{2} \times 1.5 \times 10^3\text{ kg} \times (13.4\text{ m s}^{-1})^2 = 1.35 \times 10^5\text{ J}$ Transfer of KE = $4.54 \times 10^5\text{ J} - 1.35 \times 10^5\text{ J} = 3.19 \times 10^5\text{ J}$ $3.19 \times 10^5\text{ J} = 3750\text{ N} \times d$ $d = 85.1\text{ m}$	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**3**
	Total for question		**4**

Question Number		Mark
3 (a)	Use of suitable equation(s) of motion to find distance (1) Height = 7.4 (m) (1) (accept 9.8(1)/6 or 1.635 for acceleration but do not accept g/6 as a substitution if final answer is wrong and looking to award MP1 only) (a reverse argument leading to t = 2.9 s can score both marks) <u>Example of calculation</u> $s = ½ at^2$ s = ½ x (9.81 m s^{-2} / 6) x (3 s)^2 s = 7.4 m	**2**
3 (b)(i)	Use of trig function appropriate to calculate vertical component of velocity **Or** 10.1 (m s^{-1}) seen (1) Use of suitable equation(s) of motion to find time (1) t = 12.4 (s) (1) (if v and u not consistent with sign of g max 2 marks. Calculation can be done for total time of 12.3 s with either total displacement =0 or u=-v) <u>Example of calculation</u> u = 18 m s^{-1} x sin 34° = 10.1 m s^{-1} $v = u + at$ 0 = 10.1 m s^{-1} – (9.81 m s^{-2} / 6) x t t = 6.2 s to max height time of flight = 12.4 s	**3**
3 (b) (ii)	Use of trig function appropriate to calculate horizontal component of velocity **Or** 14.9 (m s^{-1}) seen **Or** Use of Pythagoras (1) Use of suitable equation(s) of motion to find distance (1) Distance = 185 (m) (ecf time value from part (i)) (1) <u>Example of calculation</u> v= 18 m s^{-1} × cos 34° = 14.9 m s^{-1} $s = vt$ =14.9 m s^{-1} ×12.4 s s = 185.0 m	**3**

***3 (c**	*lower gravitational field strength*: lower acceleration (1) the idea of an increased time of flight (1) (do not accept slower in place of lower) *lack of atmosphere:* no work done against friction **Or** no slowing/deceleration due to friction (1) (accept air resistance or drag for friction)	**3**
	Total for question	**11**

Question Number		Mark
4(a)(i)	Weight (1) (accept *W* or mg or gravitational pull/force) ('gravity' doesn't get the mark) Tension (1) (accept *T*) (Both arrows and labels required for each marking point)  (Arrows must touch mass for marks; ignore any arrows, for correct or incorrect forces, not touching (Minus one from maximum possible mark for each additional force (e.g. resultant, pull) or other arrow (e.g. speed or motion) touching mass)	**2**
4(a) (ii)	A triangle or parallelogram with W and T in correct position for vector addition with correct labels and directions. (1) Triangle or parallelogram completed correctly with resultant in correct directions. (1) (Can score 2 marks even if the resultant is not horizontal) e.g. (scores 2 marks)  	**2**

5(a) (iii)	$ma/mg = \tan \theta$ **OR** $T \cos \theta = mg$ **and** $T \sin \theta = ma$ (1) (seen or substituted into) $a = 1.2$ (m s^{-2}) (1) <u>Example of calculation</u> $a = \tan 7^{\circ} \times g = \tan 7^{\circ} \times 9.81\ \text{m s}^{-2}$ $= 1.2\ \text{m s}^{-2}$	**2**
5(b)(i)	Straight down (by eye) (1) 	**1**
5(b) (ii)	To left, angle between string and roof to be less than 83º but not horizontal (1) 	**1**
5(b) (iii)	To right, at any angle except horizontal (1) 	**1**
5 (c)	Always has weight **Or** gravitational force **Or** force due to gravity (1) so tension needs a vertical component (1) **Or** Use of the equation $ma/mg = \tan \theta$ (1) Leading to the idea of infinite value of $\tan \theta$ requiring infinite acceleration (1)	**2**
5 (d)	Any correct physics answer that uses the concept of the independence of motion at right angles (1) e.g. (to detect movement) in the x,y,z directions/planes/axes **Or** up-down, left-right and forwards-backwards	**1**
	Total for question	**12**

Question Number	Answer	Mark
6 (a)	Explain this demonstration and the need for the precautions. QWC – spelling of technical terms must be correct and the answer must be organised in a logical sequence Max 4 from this part It will not strike the student's face / at most will just touch / returns to starting point The total energy of the pendulum is constant / energy is conserved It cannot move higher than its starting point … … because that would require extra gpe (consequent on previous mark) Mention specific energy transfer: gpe → ke / ke → gpe Energy dissipated against air resistance … … will stop it quite reaching its starting point (consequent on attempt at describing energy loss mechanism) Max 4 from this part Pushing does work on the ball / pushing provides extra energy If pushed, it can move higher (accept further) … will hit the student If the face moves (forward) the ball may reach it (before it is at its maximum height) OR if the face moves (back) the ball won't reach it	 **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **Max 6**
6 (b) (i)	Calculate the gravitational potential energy gained by the ball. Use of gpe = *mgh* Correct answer (100 J) <u>Example of calculation</u> gpe = *mgh* $= 7\text{ kg} \times 9.81\text{ N kg}^{-1} \times 1.5\text{ m}$ = 103 J	 **(1)** **(1)**
6 (b) (ii)	Calculate the speed of the ball at the bottom of its swing Use of ke = $1/2\ mv^2$ Correct answer (5.4 m s^{-1}) <u>Example of calculation</u> $103\text{ J} = 1/2\ mv^2$ $v = \sqrt{(2 \times 103\text{ J} / 7\text{ kg})}$ $= 5.4\text{ m s}^{-1}$ (Use of 100 J → 5.3 m s^{-1})	 **(1)** **(1)**
	Total for question	**10**

Question Number	Answer	Mark
7(a) (i)	Show that the power available to the turbine is about 40 kW. Use of density = *m/V* (1) Use of gpe = *mgh* (1) Correct answer [38 000 W] (1) [no ue] *Example of calculation* volume in 1 s = 0.13 m^3 mass = density x V = 1000 kg m^{-3} x 0.13 m^3 (1) = 130 kg gpe lost = *mgh* = 130 kg x 9.81 N kg^{-1} x 30 m = 38 000 J in one second, so power = 38 000 W [1000 kg m^{-3} x 0.13 m^3 x 9.81 N kg^{-1} x 30 m = 38 000 W gets 3 marks]	**3**
7(a) (ii)	Suggest a reason for output only 6 kW friction e.g. in turbine, in fluid / flow rate lower / heat due to friction [accept (electrical) resistance in turbine] (1)	**1**
7(b) (i)	Calculate maximum output of solar system for 6 hours Use of energy = power x time(1) Correct answer [216 MJ] (1) *Example of calculation* Energy = power x time = 10 000 W x 6 x 60 x 60 s = 2.16 x 10^8 J [216 000 000 J, 216 MJ, 216 000 kJ]	**2**
7(b) (ii)	Discuss suitability of output of diesel generators Renewables – 100 + 6 + 6 + 24 + 10 = 146 kW [accept 140 kW], vs diesel 160 kW (1) Backup must be enough to replace whole of renewable amount / diesel power greater than or approximately equal to renewable(1)	**2**
	Total for question	**8**

Question Number	Answer		Mark
8(a)	work done = energy transferred **Or** Work done (against gravity) is equal to the (gain in) gravitational potential energy The distance moved is the height the box is raised by **and** the force to be used must be equal to the weight **Or** $\triangle h = \triangle s$ **and** $F = mg$	(1) (1)	**2**
8(b)	Use of $\Delta E_{grav} = mg\Delta h$ $\Delta E_{grav} = 74$ J <u>Example of calculation</u> $\Delta E_{grav} = 5.0 \text{ kg} \times 9.81 \text{ N kg}^{-1} \times 1.5 \text{ m}$ $\Delta E_{grav} = 73.6$ J	(1) (1)	**2**
	Total for Question		**4**