Question Number	Answer		Mark
1(a)(i)	Use of *F* cos 42º or *F* sin48º Horizontal component = 480 (N) <u>Example of calculation</u> Horizontal component = 650 N x cos 42º = 483 (N)	**(1)** **(1)**	 **2**
1(a)(ii)	Use of $\Delta W = F\Delta s$ Work = 51 000 J <u>Example of calculation</u> Work = 483 N x 15 x 7 m = 50 715 J	**(1)** **(1)**	 **2**
1(b)	Force in the direction of motion **Or** Force is parallel to the direction of motion **Or** Force is applied in a horizontal direction **Or** There is no vertical component of force So less applied force	 **(1)** **(1)**	 **2**
	Total for question		**6**

Question Number	Answer	Mark
2(a)	Wind exerts a force/push(on the blades) **(1)** blades move (through a distance in the direction of the force) **(1)** **Or** Energy is transferred **(1)** From kinetic energy of wind to (KE of) the blades **(1)**	**2**
2(b)(i)	Use of volume = area x length **(1)** Volume = 270 000 (m^3) **(1)** <u>Example of calculation</u> Volume per second = 6 000 $m^2 \times 9$ m = 54 000 m^3 Total volume in 5 seconds = 54 000 $m^3 \times 5$ s = 270 000 (m^3)	**2**
2(b(ii)	Use of mass = density x volume **(1)** Mass = 324 000 kg (ecf) **(1)** <u>Example of calculation</u> Mass = 1.2 kg $m^{-3} \times$ 270 000 m^3 = 324 000 kg	**2**
2(b)(iii)	Use of $E_k = 1/2\ mv^2$ **(1)** E_k =1.3 x 10^7 J (ecf) **(1)** <u>Example of calculation</u> E_k = ½ × 324 000 kg × (9 m $s^{-1})^2$ = 13 122 000 J	**2**
2(b)(iv)	**Use of either** Energy from wind over 5 second period = 59 % x E_k **Or** KE divided by 5(s) **(1)** Power = 1.5 MW **(1)** [Range of correct answers 1.5 MW to 1.8MW] <u>Example of calculation</u> Energy from the wind in 5 seconds = 0.59 × 13 100 000 J = 7 741 980 J Power = energy/second = 7 741 980 J/5 s = 1.548 MW	**2**
2(c)	Would need to stop wind entirely/Wind or air still moving/Wind or air still has KE/Not all the air hits the blades **(1)**	**1**
2(d)	**Max 2** • Wind doesn't always blow/if there is no wind they don't work/ wind speeds are variable/ need minimum amount of wind to generate the electricity/need a large amount of wind/can't be used in very high winds **(1)** • Only 59 % max efficiency **(1)** • Low power output/Need a lot of turbines/ Need a lot of space **(1)**	**2**
	Total for question	**13**

Question Number	Answer	Mark
3 (a)	Show that the work done by the horse in turning the wheel once was about 20 000 J. Use of distance = $2 \pi r$ **(1)** Use of work = force x distance **(1)** Correct answer (19 000 (J) to at least 2 sf) **(1) [no ue]** (If force x 3.7 m used, allow second mark only) (If force x distance for 144 turns used, allow 1st and 2nd marks) *Example of calculation* $x = 2 \times \pi \times 3.7$ m = 23.2 m $W = F\Delta x$ =800 N x 23.2 m = 18 600 J ('Reverse show that' starting from 20 000J – max 2)	**(3)**
3 (b)	Calculate the average power of the horse Recall power is rate at which work is done (accept formula or substituted values) **(1)** Substitute for 144 turns **(1)** Correct answer (740 W) **(1)** If using P = Fv: Recall P = Fv **(1)** Use of v = s/t for 144 turns **(1)** Correct answer **(1)** *Example of calculation* Power = work done / time = 144 x 18 600 J / 60 x 60 s = 744 W (accept any dimensionally correct unit – ignore later units if W used as well) (use of 20 000 J gives 800 W)	**(3)**
	Total for question	**6**

Question Number	Answer	Mark
4(a)	Calculate maximum energy Use of *gpe* = *mgh* **(1)** Correct answer (0.28 J) **(1)** *Example of calculation* *gpe* = *mgh* = 0.41 kg x 9.81 N kg^{-1} x 0.07 m = 0.28 J [N.B. Bald answer gets 2, but no marks if derived from use of $v^2 = u^2 + 2as$]	**(2)**
4(b)	Resolve this velocity into horizontal and vertical components. Shows a correct, relevant trigonometrical relationship **(1)** Correct answer for horizontal component (12 m s^{-1}) **(1)** Correct answer for vertical component (10 m s^{-1}) **(1)** (max 1 mark total for reversed answers) (apply ue once only) *Example of calculation* $v_h = v \cos\theta$ = 16 m s^{-1} x cos 40° = 12.3 m s^{-1} $v_v = v \sin\theta$ = 16 m s^{-1} x sin 40° = 10.3 m s^{-1}	**(3)**
4(c)	Explain another reason why the projectile does not go as far as expected. (QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Max 2 out of three marking points for: A physical cause – e.g. other parts of the machine are moving/the sling stretches/headwind/fired up a slope/the projectile increases in height before release **(1)** Description of **energy** elsewhere than the projectile – e.g. elastic energy in sling/moving parts have ke / projectile has gained gpe before launch [Must refer to energy] **(1)** Stating that less energy has been transferred to the projectile/projectile has a lower speed **(1)**	**(max 2)**
	Total for question	**7**

Question Number	Answer	Mark
5(a)	Calculate the resistive forces State component of $T = T\cos\theta$ (1) Correct answer [1120 N] (1) **Example of calculation** $T = T\cos\theta$ = 1150 N x cos 12° = 1125 N Therefore resistive forces = 1125 N	**2**
5(b)	Calculate the work done on the boat by the horse Use of $\Delta W = F\Delta s$ (1) Correct answer [558 000 J] (1) [ecf] **Example of calculation** $\Delta W = F\Delta s$ = 1125 N x 500 m =560 000 J	**2**
5(c)	Explain using a longer rope Longer rope → smaller angle (1) cos theta then larger / need smaller force (for same component acting on boat) (1)	**2**
	Total for question	**6**

Question Number		Mark
6(a) (i)	Use of equation of motion suitable for a, e.g. $v = u + at$ (1) a = 16.3 m s^{-2} (2.1 ×10^{5} km h^{-2} or 58.7 km h^{-1} s^{-1}) (1) <u>Example of calculation</u> $a = \frac{37.5\text{ m s}^{-1} - 0}{2.3\text{ s}}$ a = 16.3 m s^{-2}	**2**
6(a) (ii)	Use of $E_k = ½\, mv^2$ (1) Use of $P = E/t$ (1) Power = 3.1×10^{6} W (1) **Or** Use of $F = ma$ (must be a from (i)) **and** Use of equation to find distance **and** use of work done = Fd (1) Use of $P = E/t$ (1) Power = 3.1 × 10^{6} W (1) (distance = 43 m) <u>Examples of calculations</u> E_k = ½ × 10 000 kg × (37.5 m s^{-1})^2 = 7.03 ×10^{6} J Power = 7.03 × 10^{6} J / 2.3 s = 3.1 × 10^{6} W	**3**
6(a) (iii)	Energy transferred by heating **Or** energy transferred due to friction **Or** work done against friction **Or** idea that more energy required (due to energy transfer) due to friction. (1) (do not accept 'lost' but accept air resistance as an alternative to friction)	**1**
***6(b**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) larger force is needed **Or** the (same) force is insufficient (1) need same acceleration/ (max) velocity **OR** acceleration/(max) velocity is too small (1) more energy needed (to reach top) **Or** insufficient energy (to reach top) (1)	**3**
6 (c)	Viscosity of oil decreases (with increasing temperature) **Or** the (warm) oil is less viscous (1) (accept a reverse argument e.g. when cold oil is more viscous) Lower frictional/resistive force **Or** less viscous drag (1)	**2**
	Total for question	**11**

Question Number	Answer		Mark
7(a)	Static domino now has an unbalanced force acting on it so starts to move/fall **Or** falls from rest **Or** accelerates **Or** Before it is hit, the static domino has no unbalanced force on it (so) remains at rest	**(1)** **(1)** **(1)** **(1)**	**2**
***7(b)**	**(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate)** <u>The bottom coin is knocked out from under the stack</u> Only the bottom coin is given a force **Or** bottom coin has an unbalanced force on it Bottom coin starts to move **Or** accelerates <u>The flicked coin stops</u> Stacked/bottom coin gives the flicked coin a force **Or** force on flicked coin due to N3. The resultant force on the flicked coin is opposite to the direction of motion **Or** the flicked coin decelerates <u>The stack drops down</u> The remaining stacked coins do not receive any horizontal force (so stay still horizontally) The stacked coins now have an unbalanced vertical force (and drop) **Or** there is now only weight acting (vertically)	 **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**6**
7(c)	The idea that the direction of the (force of the flicked) coin on the stack is in a different direction (to initial direction of travel) The idea that the force from stack on (flicked) coin is in a different direction (to initial direction of travel) (Accept a labelled diagram indicating an off-centre collision)	**(1)** **(1)**	**2**
	Total for question		**10**