Question Number	Answer	Mark
1(a)(i)	So that it can store/transfer elastic/strain (potential) energy **Or** to produce a (restoring) force on the arm (1) (accept pull for force i.e. ‘pull arm up’)	**1**
1(a)(ii)	Elastic/strain (potential) energy → E_{grav} +/and E_k (+/and thermal energy) (1)	**1**
***1(b)(i**	(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate) **Either** (the greater the angle) the greater the energy (stored) (1) greater kinetic energy (transferred to projectile/arm) (1) greater (initial) (horizontal) velocity of the projectile (1) $s = ut$ linked to a greater range (1) **Or** the greater the angle the greater the force/stress/tension (1) the greater the acceleration (of the arm/projectile) (1) greater (initial) (horizontal) velocity of the projectile (1) $s = ut$ linked to a greater range (1) (Accept symbols for words)	**4**
1(b)(ii)	Increases acceleration **Or** increases (initial) velocity (of the projectile) (1)	**1**

1(b)(iii)	One modification (1) One reason (1) (Modification and reason must be linked for both marks to be awarded) **Modification** / **Reason** Double up or increase number of bands / Would increase the force/tension **Or** would increase energy (stored) **Or** would increase the work done Replace with bands that are: stiffer or shorter or wider or have greater *k* (not smaller) / Would increase the force/tension **Or** would increase energy (stored) **Or** would increase the work done Use a longer arm or raise the device to a greater height / Greater (vertical) distance to fall Tilt the model or cross bar / Projectile launched with an upwards component of velocity or at an angle		**2**
1(c)(i)	Use of $s = ut + ½ at^2$ $t = 0.13$ (s) <u>Example of calculation</u> $0.08 \text{ m} = ½ \times 9.81 \text{ m s}^{-2} \times t^2$ $t = 0.128$ s	(1) (1)	**2**
1(c)(ii)	Use of $v = s/t$ to calculate horizontal speed **Or** see 10.6 (m s^{-1}) Use of $s = 10.6 \times t$ $s = 1.4$ m ecf for time from (i) (using show that value $s = 1.06$ m) <u>Example of calculation</u> $u_{\text{horizontal}} = \frac{1.70 \text{ m}}{0.16 \text{ s}} = 10.6 \text{ m s}^{-1}$ $s = 10.6 \text{ m s}^{-1} \times 0.13 \text{ s}$ $s = 1.38$ m	(1) (1) (1)	**3**
	Total for question		**14**

<table>
<tr><th>Question Number</th><th>Answer</th><th></th><th>Mark</th></tr>
<tr><td>2(a)</td><td>
<table>
<tr><th>Stage of jump</th><th>Energy transfer</th></tr>
<tr><td>freefall jump</td><td>Gravitational potential energy → kinetic energy</td></tr>
<tr><td>deceleration as the bungee rope stretches</td><td>Gravitational potential energy and/or kinetic energy→ elastic potential/strain energy</td></tr>
<tr><td>upwards motion as the bungee rope contracts</td><td>Elastic potential/strain energy → gravitational potential energy and kinetic energy</td></tr>
</table>
(Ignore any additional energy transfers e.g. due to the effects of air resistance)
(Only penalise once for an omission of potential or strain with elastic or gravitational potential energy)</td><td>(1)

(1)</td><td>2</td></tr>
<tr><td>2(b)(i)</td><td>Use of $E_{grav} = mgh$ (with either 65 m or 55 m)
E_{grav} = 29 (kJ)

<u>Example of calculation</u>
$E_{grav} = 54\ \text{kg} \times 9.81\ \text{N kg}^{-1} \times 55\ \text{m}$
$E_{grav} = 2.91 \times 10^4\ \text{J}$</td><td>(1)
(1)</td><td>2</td></tr>
<tr><td>2(b)(ii)</td><td>Calculation of the extension Or (55 – 23) seen
Use of $E = ½F\Delta x$ to find force
F = 1800 N (ecf from (b)(i))

(Using show that value F = 1875 N)

<u>Example of calculation</u>
Δx= 55 m – 23 m = 32 m
F = [illegible]
F = 1813 N</td><td>(1)
(1)
(1)</td><td>3</td></tr>
<tr><td></td><td>Total for Question</td><td></td><td>7</td></tr>
</table>

<table>
<tr><th>Question Number</th><th>Answer</th><th></th><th>Mark</th></tr>
<tr><td>3</td><td>Explanation in terms of N3 (stated or implied)
e.g due to N3, magnet A exerts a force on magnet B
Or magnet A exerts a force on magnet B and magnet B exerts an equal and opposite force on magnet A
Or the magnets exert equal and opposite forces on each other

The idea that the magnets are connected to the same body/each other

There will be no resultant force
Or the two (applied) forces will cancel out
Or forces balance/equilibrium</td><td>(1)

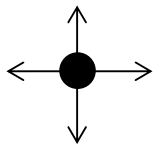
(1)

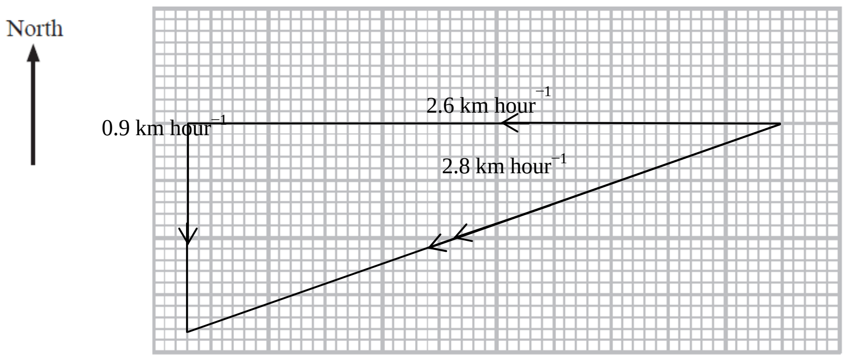
(1)</td><td>3</td></tr>
<tr><td></td><td>Total for Question</td><td></td><td>3</td></tr>
</table>

Question Number	Answer		Mark
4(a)(i)	Use of work done = force × distance Work done = 91(J) <u>Example of calculation</u> Work done = 65 N × 1.4 m Work done = 91 J	(1) (1)	**2**
4(a)(ii)	Use of power = $\frac{\text{work done}}{\text{time}}$ Power = 83 W (ecf from (a)(i)) (Show that value gives P = 82.5 W) <u>Example of calculation</u> Power = $\frac{91 \times 55}{60\ \text{s}}$ Power = 83.4 W	(1) (1)	**2**
***4(b)(i**	(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate) Velocity is decreasing **Or** the swimmers are decelerating Rate of change of velocity decreases **Or** deceleration/acceleration decreases **Or** Drag force decreases as speed decreases Glide 2 has a greater drag/resistance/friction Explanation of why the drag force of 2 is greater than 1 e.g. cross sectional area is greater **Or** more turbulent flow **Or** less streamlined	 (1) (1) (1) (1)	**4**
4(b)(ii)	See: $C \times \text{kg m}^{-3} \times \text{m}^2 \times (\text{m s}^{-1})^2$ (in equation) See force/ N /LHS = kg m s^{-2} <u>Example</u> $\text{kg m s}^{-2} = C \times \text{kg m}^{-3} \times \text{m}^2 \times \text{m}^2\ \text{s}^{-2}$ $C = \frac{\text{kg m s}^{-2}}{\text{kg m}^{-3} \times \text{m}^2 \times \text{m}^2\ \text{s}^{-2}}$ $C = \frac{\text{kg m s}^{-2}}{\text{kg} \times \text{m} \times \text{s}^{-2}}$	(1) (1)	**2**

4(b)(iii)	Wear tight fitting clothes **Or** swimming hats **Or** body shaving **Or** wear fastskins (1) To reduce turbulent flow **Or** the idea that there will be more laminar flow **Or** reduce <u>viscous</u> drag (of water) (1) **Or** Keep their body as flat as possible in the water (1) to keep their cross sectional area as small as possible (1) **Or** Roll the body as they swim (1) To reduce the size of the waves created (1) **Or** Swim at a slower speed (1) as velocity(^{2}) of the swimmer is proportional to the drag (1) (Do not credit references to increasing the temperature of the water, reducing the density of the water, wearing smooth clothes, using oil)	**2**
	Total for question	**12**

Question Number	Answer		Mark
5	**Applied force:** The 25° slope requires a smaller force (accept converse) **Or** Use of trig to calculate the component of weight along either slope (350 (N) for 25° slope or 480 (N) for 35° slope) **Distance travelled:** The distance travelled is greater for the 25° slope (accept converse) **Or** Use of trig to calculate the distance along either slope (860 – 870 (m) for 25° slope or 630 – 640(m) for 35° slope) **Work done:** The 25° side uses smaller force over greater distance (accept converse) **Or** The work done (against gravity) is the same **Or** Correctly calculate work done to reach top (either vertically or along slope) (Work done = 3.0×10^5 (J) or 3.1×10^5 (J)) <u>Example of calculation</u> F_{25}= 85 kg × 9.81 N kg^{-1} × cos (90° - 25°) = 352.4 N F_{35} = 85 kg × 9.81 N kg^{-1} × cos (90° - 35°) = 478.3 N $d_{25°}$ = 365 m/sin25° = 864 m $d_{35°}$ = 365 m / sin 35° = 636 m Work done $_{25}$ = 352 N × 864 m = 3.04×10^5 J **and** Work done $_{35}$ = 478 N × 636 m = 3.04×10^5 J Work done = 85 kg × 9.81 N kg^{-1} × 365 m = 3.04×10^5 J	(1) (1) (1)	3
	Total for Question		**3**

Question Number	Answer		Mark
6(a)(i)	Upthrust/U  Tension/T/ Pull of (tug) boat	**(1)** **(1)**	 **2**
6(a)(ii)	Tension (in ropes) = drag force **Or** force (on iceberg) from tug boat = drag force Use of drag force = $2T\cos\theta$ (with either 15° or 30°) Correct answer = 1.7×10^5 (N) <u>Example of calculation</u> $2T \times \cos 15^\circ = 3.3 \times 10^5$ N $T = 1.7 \times 10^5$ N	 **(1)** **(1)** **(1)**	 **3**
6(a)(iii)	Use of work done = force × distance Work done = 1.7×10^{10} J (ecf) <u>Example of calculation</u> Work done = 3.3×10^5 N $\times 50 \times 10^3$ m Work done = 1.65×10^{10} J (Accept $2 \times 1.7 \times 10^5$ N $\times \cos 15^\circ$ x 50×10^3 m $= 1.64 \times 10^{10}$ J **Or** $2 \times 2 \times 10^5$ N $\times \cos 15^\circ$ x 50×10^3 m $= 1.93 \times 10^{10}$ J)	**(1)** **(1)**	 **2**
6(a)(iv)	No effect on the motion **Or** the iceberg will travel at the same speed The tug applies the same forward force on the iceberg **Or** the resultant tension is the same **Or** tension (in each rope) decreases	**(1)** **(1)**	 **2**

<table>
<tr><td>6(b)</td><td>

2 velocity lines with a resultant
(an attempt at either triangle or parallelogram vector diagram)

Correct complete vector diagram to scale with arrows

Magnitude of velocity of 2.8 km hour^{-1} (Accept 2.5 to 3.0 km hour^{-1})
And direction of 71° (± 2°) Or 19°(± 2°) Or 251 ° (± 2°)

(The third marking point may be awarded even if no vector diagram drawn)</td><td>(1)

(1)

(1)</td><td>3</td></tr>
<tr><td>6(c)</td><td>Upthrust = weight (of iceberg)
Or upthrust = weight (of water displaced)
Or weight of iceberg = weight of water displaced

State or use of upthrust/weight = density × V × g
Or
Calculation of both volumes using the mass = 3×10^9 kg
($V_{iceberg} = 3.3 \times 10^6\ m^3$ and $V_{submerged} = 2.9 \times 10^6\ m^3$)

Proportion = 0.89

<u>Example of calculation</u>
Upthrust = $1030\ kg\ m^{-3} \times V_{submerged} \times g$

$1030\ kg\ m^{-3} \times V_{submerged} \times g = 920\ kg\ m^{-3} \times V_{iceberg} \times g$

$V_{submerged} / V_{iceberg} = 920\ kg\ m^{-3} / 1030\ kg\ m^{-3} = 0.89$</td><td>(1)

(1)

(1)</td><td>3</td></tr>
<tr><td>6(d)</td><td><table><tr><th>Physical Quantity</th><th>Relative effect</th></tr><tr><td>Sea temperature</td><td>Increases</td></tr><tr><td>Viscosity</td><td>Decreases</td></tr><tr><td>Density of sea water</td><td>Decreases</td></tr><tr><td>Position in the water of the iceberg</td><td>Lower/sinks</td></tr></table>
All 4 statements correct - 2 marks
2 or 3 statements correct – 1 mark only</td><td>(2)
(1)</td><td>2</td></tr>
<tr><td></td><td>Total for Question</td><td></td><td>17</td></tr>
</table>