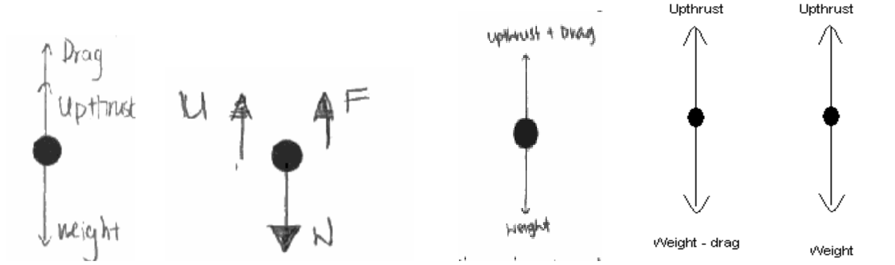
<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>1(a)(i)</td><td>Upthrust/U
Weight/W/mg/gravitational force/force due to gravity
(Viscous) drag/fluid resistance/friction/F/D/V

(3 correct = 2 marks, 2 correct = 1 mark. All arrows must touch the dot and straight, vertical lines required, no curving around dot, arrows can be of any length)



2 marks 0 marks 2 marks arks 1 mark</td><td>2</td></tr>
<tr><td>1(a)(ii)*</td><td>(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate)

Initially viscous drag = 0 OR viscous drag is very small
OR resultant force is downwards OR $W > U$ OR $W>U + D$ (1)

Viscous drag increases (1)

(Until) forces balanced OR resultant/net force zero OR forces in equilibrium (1)

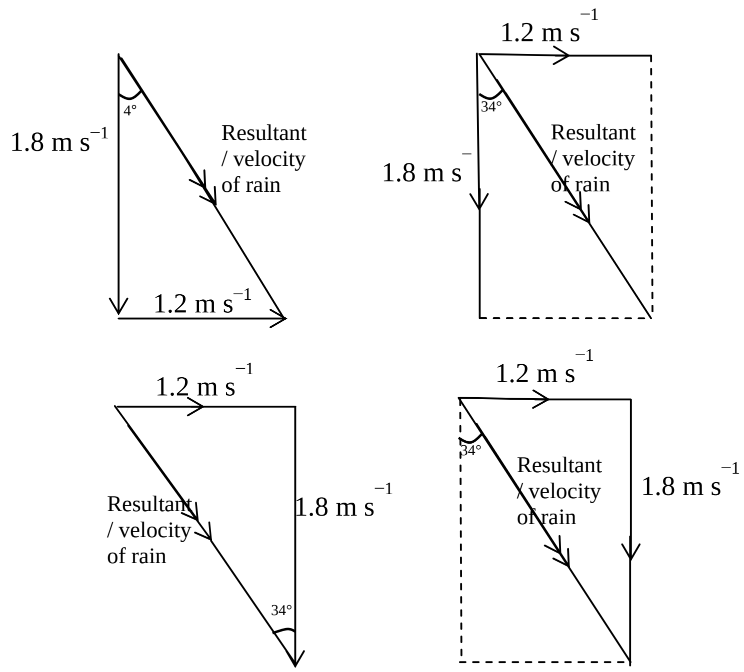
(Therefore) no <u>acceleration</u> (1)

(To gain all 4 marks, any letters used to indicate forces must be defined in either parts (a)(i) or (a)(ii)).</td><td>4</td></tr>
<tr><td>1(a)(iii)</td><td>$W = U + D$ (allow ecf from diagram in part (a)(i)) (1)</td><td>1</td></tr>
</table>

Question Number	Answer		Mark
1(b)(i)	Use of mass = density × volume Upthrust = 2.1×10^{-5} (N) <u>Example of calculation</u> Mass = 1.0×10^{3} kg m^{-3} × 2.1×10^{-9} m^{3} = 2.1×10^{-6} kg Upthrust = 2.1×10^{-6} kg × 9.81 N kg^{-1} = 2.1×10^{-5} N	**(1)** **(1)**	**2**
1(b)(ii)	State or use viscous drag = W – U ($F = 3.6 \times 10^{-5}$ N) Use of $F = 6\pi\eta rv$ Speed = 2.0 m s^{-1} (ecf from (b)(i)) <u>Example of calculation</u> $F = 5.7 \times 10^{-5}$ N – 2.1×10^{-5} N = 3.6×10^{-5} N $v = \frac{3.6 \times 10^{-5}\ \text{N}}{6\pi\eta r}$ $= \frac{3.6 \times 10^{-5}\ \text{N}}{6 \times \pi \times 1.2 \times 10^{-3}\ \text{Pa s} \times 8 \times 10^{-4}\ \text{m}}$ = 2.0 m s^{-1}	**(1)** **(1)** **(1)**	**3**
1(c)	larger particles have higher terminal/maximum/average velocity **OR** smaller particles reach terminal velocity quicker **MAX 2** Viscous drag varies in proportion to radius (or area in proportion to radius squared) but weight varies in proportion to radius cubed (terminal) velocity proportional to radius squared	**(1)** **(1)** **(1)** **(1)**	**3**
	Total for question		**15**

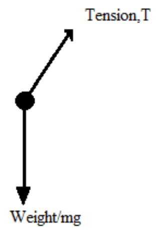
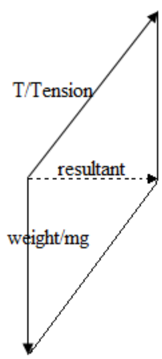
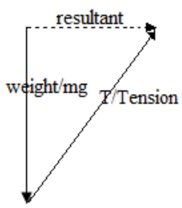
Question Number	Answer	Mark
2(a)	Sketch a vector diagram Correct diagram – closed polygon, accept a triangle using the resultant of lift and weight, but arrows must follow correctly. Must show sequence of tip-to-tail arrowed vectors.	 **(1)**
2(b)	Find the tension in the string. Use of trigonometrical function for the horizontal angle (allow mark for vertical angle if correct and shown on dia) Correct answer for <u>horizontal</u> angle (32.8°) Use of Pythagoras or trigonometrical function for the tension Correct answer for tension magnitude (7.1 N) <u>Example of calculation</u> weight – lift = 3.86 N from horizontal, tan (angle) = 3.86 N/ 6.0 N angle = 32.8° $T^2 = F_h^2 + F_v^2$ $= (6.0\ \text{N})^2 + (3.86\ \text{N})^2$ $T = 7.1$ N	 **(1)** **(1)** **(1)** **(1)**
2(c) (i)	Calculate the work done by the girl. Use of $W = Fs$ Correct answer (150 J) <u>Example of calculation</u> $W = Fs = 6.0$ N x 25 m = 150 J	 **(1)** **(1)**
2(c) (ii)	Calculate rate at which work is done Finds time Correct rate (12 W) <u>Example of calculation</u> $t = s/v = 25\ \text{m} / 2.0\ \text{m s}^{-1} = 12.5\ \text{s}$ $P = 150\ \text{J} / 12.5\ \text{s}$ = 12 W	 **(1)** **(1)**
	Total for question	**9**

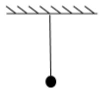
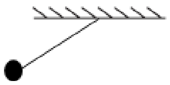
Question Number	Answer	Mark
3 (a)	Free body diagram. Weight / *W* / *mg* (NOT ‘gravity’) – correctly labelled arrow (allow force/pull of gravity) (1) Normal contact force / force/push of table / ‘reaction’ / *R* – correctly labelled arrow (1) [3 forces labelled – max 1mark, 4 forces – no marks BUT ignore upthrust.] [The free-body diagram does not have to include the bottle but the forces must be co-linear for the second mark]	**2**
3 (b)	Give a corrected explanation. ***(Newton) 3rd law*** $\rightarrow$ *eq and opp (1)* by **(Newton) 1st law** (accept 2nd law) (1) forces balanced $\rightarrow$ no **acceleration** / no **change in velocity** / **remains at rest** (1) [Bold type indicates required changes]	**3**
	Total for question	**5**

Question Number	Answer		Mark
4	An attempt at a vector diagram constructed with 1.8 vertically and 1.2 horizontally (accept any labelling in ratio of 3:2)	(1)	
	Correct vector diagram with velocities labelled (as in MP1) and velocities and resultant in the correct direction	(1)	
	Diagram to scale, either scale stated or lengths in ratio 3:2	(1)	
	$v = 2.2\ \mathrm{m\ s^{-1}} \pm 0.1\ \mathrm{m\ s^{-1}}$	(1)	
	Direction = 34° ± 1°	(1)	**5**
	<u>Example of calculation</u> $v = \sqrt{1.8^2 + 1.2^2}$ $v = 2.16\ \mathrm{m\ s^{-1}}$ e.g. for walking to the right (reverse for walking to the left) 		
	Total for Question		**5**

Question Number	Answer	Mark
5(a)	Add labelled arrows to show the other forces on the submarine. Label upthrust, weight and viscous drag: 3 correct (2), 1 or 2 correct (1) (Accept unambiguous single letter labels, e.g. U, W and V/F/D/VD) (Accept *mg* for weight but do not accept 'gravity')	**2**
5(b)	State two equations to show the relationship between the forces Upthrust = (-)Weight (1) Thrust = (-)Viscous drag (1)	**2**
5(c)	Show that the submarine has a weight of about 7×10^7 N. Use of density = m/V (1) Correct answer [7.2×10^7 N to at least 2 s.f.] (1) [no ue] **Example of calculation** calculate weight of water as U = W m = density x volume $= 1030 \text{ kg m}^{-3} \times 7\,100 \text{ m}^3$ $= 7.3 \times 10^6$ kg W = mg $W = 7.3 \times 10^6 \text{ kg} \times 9.81 \text{ N kg}^{-1}$ $= 7.2 \times 10^7$ N	**2**

5(d) (i)	Explain what is meant by compressive strain. decrease in length / original length (1)	**1**
5(d) (ii)	Explain the action that should be taken pump out water / replace water in tanks with air (1) to decrease weight (accept mass) / to compensate for decreased upthrust / to make density the same as water (1)	**2**
5(d) (iii)	Suggest why a material like fibreglass would be unsuitable **QWC – Work must be clear and organised in a logical manner using technical wording where appropriate** A much greater (compressive) strain will be produced / compresses more easily (1) producing a larger decrease in volume/upthrust/deformation (1)	**2**
	Total for question	**11**

Question Number		Mark
6(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**
6(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**

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