

3	The only correct answer is B because Upthrust is equal to weight of sphere (2.5 N). Weight of displaced water if half sphere submerged = 2.5 N Weight of displaced water if all of sphere submerged = 5.0 N Total upwards force acting on sphere when completely submerged = 5.0 N Total downwards force on sphere if completely submerged (and stationary) = 5.0 N <i>F</i> must be equal to 2.5 N A is not the correct answer as $F = 2.5\text{ N}$ C is not the correct answer as $F = 2.5\text{ N}$ D is not the correct answer as $F = 2.5\text{ N}$	(1)
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7	B decreased by $(2.4 \times 10^{-5}) \times (1000) \times (9.81)$ Incorrect Answers: A – this is just the mass of the displaced water C – the reading will decrease and not increase due to the upthrust acting upwards on the object by the weight, and not the mass, of the displaced water (upthrust) D – the reading will decrease and not increase due to the upthrust acting upwards on the object	1
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1	The only correct answer is D (<i>W</i>) A is not correct because upthrust is equal to the weight of liquid displaced B is not correct because upthrust is equal to the weight of liquid displaced C is not correct because upthrust is equal to the weight of liquid displaced	1
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Question Number	Answer	Mark
19(a)	• Upthrust/<i>U</i> upwards (1) • Tension/<i>T</i> upwards (1) • Weight/<i>W</i>/<i>mg</i> downwards (1) (-1 for each extra force over three, -1 if any arrow does not touch the dot, -1 if any arrow is not close to vertical. Accept a single line up with two labelled arrowheads.)	(3)
19(b)(i)	• Water exerts upward force on sphere. (1) Or Water exerts an upthrust on the sphere. • Sphere exerts a downwards/opposite force on water by Newton's Third Law. (1) • Extra downward force on water (increases reading on balance).	(1) (3)

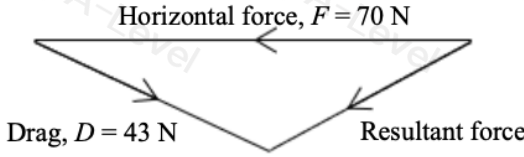
19(b)(ii)	• Mass of displaced water = 150 g (1) • Use of $V = m/\rho$ for water with $\rho = 1\,000\text{ kg m}^{-3}$ (150 ml) (1) • Use of $m = \rho V$ for sphere WITH $\rho = 2\,000\text{ kg m}^{-3}$ (1) • $m = 0.30\text{ kg}$ (1) Example of calculation Increase in weight of water = force of ball on water = upthrust on ball Mass of displaced water = $465\text{ g} - 315\text{ g} = 150\text{ g}$ Volume of sphere = $\frac{0.150\text{ kg} \times g}{1000\text{ kg m}^{-3} \times g} = 1.5 \times 10^{-4}\text{ m}^3$ Mass of sphere = $2000\text{ kg m}^{-3} \times 1.5 \times 10^{-4}$ (4)	
19(b)(iii)	• Upthrust less in oil or weight of displaced oil less or downward force of sphere on oil less (1) • (Therefore increase in) balance reading less (than for water). (1) (MP2 dependent on MP1)	(2)
Total for question 19		12

Question Number	Answer	Mark
13(a)	Distance $P = D - h$ Distance $Q = D$	(1) (1) 2
*13(b)	(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate) Max 5 A statement or description of tension = weight – upthrust (+ drag) (1) (Initially) tension constant as upthrust is constant Or (Initially) the graph is flat as upthrust is constant in water (1) The speed is slow/constant in water so friction is constant/negligible (1) As the cylinder moves through the surface of the water the volume/weight/mass of displaced water decreases (1) The tension increases because the upthrust decreases Or the tension increases as the upthrust is proportional to submerged volume (1) (Once above the water the) tension greater/constant as tension = weight Or (Once above the water the) tension greater/constant as upthrust is negligible/small (1) Accept symbols for tension, weight and upthrust but symbols must be defined if QWC awarded	5
Total for question 13		7

Question Number	Answer	Additional Guidance	Mark
17(a)	Calculates volume of one lifting bag (1) Calculates volume of box (1) Use of $\rho = \frac{m}{V}$ (1) Use of $W = mg$ (1) Total upthrust = 2700 N (1) Comparison of calculated upthrust with 2500 N and consistent conclusion (1)	<u>Example calculation</u> $V_{\text{bag}} = \frac{4}{3} \times \pi \times \left(\frac{0.5 \text{ m}}{2}\right)^3 = 0.0654 \text{ m}^3$ $V_{\text{box}} = 1.1 \text{ m} \times 0.5 \text{ m} \times 0.25 \text{ m} = 0.138 \text{ m}^3$ $V_{\text{total}} = 2 \times 0.0654 \text{ m}^3 + 0.138 \text{ m}^3 = 0.269 \text{ m}^3$ $m_{\text{displaced water}} = 1020 \text{ kg m}^{-3} \times 0.269 \text{ m}^3 = 274 \text{ kg}$ $W_{\text{displaced water}} = 274 \text{ kg} \times 9.81 \text{ N kg}^{-1} = 2690 \text{ N}$ 2690 (N) > 2500 N so the box will be lifted	6
17(b)(i)	Calculates resultant of weight and upthrust (1) Use of $F = 6\pi\eta r v$ (1) Terminal velocity = 13.0 m s⁻¹ (1)	<u>Example calculation</u> $F = 4.77 \times 10^{-4} \text{ N} - 1.82 \times 10^{-6} \text{ N} = 4.752 \times 10^{-4} \text{ N}$ $v = \frac{4.752 \times 10^{-4} \text{ N}}{6 \times \pi \times 8.60 \times 10^{-4} \text{ Pa s} \times 2.25 \times 10^{-3} \text{ m}} = 13.03 \text{ m s}^{-1}$	3

17(b)(ii)	Any two from		Ignore the bubble may not be small	2
	• The bubble may not move at a low speed	(1)		
	• The bubble may not be spherical	(1)		
	• The bubble may not experience laminar flow Or flow may be turbulent	(1)		
	• The temperature/viscosity may change (as the bubble rises)	(1)		
	• The volume/radius may change (as the bubble rises)	(1)		
Total for question 17				11

Question Number	Answer	Mark																																								
*18(b)	This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content. <table><tr><th>IC points</th><th>IC mark</th><th>Max linkage mark</th><th>Max final mark</th></tr><tr><td>6</td><td>4</td><td>2</td><td>6</td></tr><tr><td>5</td><td>3</td><td>2</td><td>5</td></tr><tr><td>4</td><td>3</td><td>1</td><td>4</td></tr><tr><td>3</td><td>2</td><td>1</td><td>3</td></tr><tr><td>2</td><td>2</td><td>0</td><td>2</td></tr><tr><td>1</td><td>1</td><td>0</td><td>1</td></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td></tr></table> The following table shows how the marks should be awarded for structure and lines of reasoning. <table><tr><th></th><th>Number of marks awarded for structure of answer and sustained line of reasoning</th></tr><tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr><tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr><tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr></table> Indicative content IC1 the resultant force on the submarine is zero IC2 So tension = weight – upthrust IC3 As the submarine leaves the water, the volume / mass / weight of water displaced decreases IC4 So the upthrust on the submarine decreases IC5 and the tension in the cable increases IC6 When the submarine is out of the water the tension in the cable is equal (in magnitude) to the weight of the submarine	IC points	IC mark	Max linkage mark	Max final mark	6	4	2	6	5	3	2	5	4	3	1	4	3	2	1	3	2	2	0	2	1	1	0	1	0	0	0	0		Number of marks awarded for structure of answer and sustained line of reasoning	Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2	Answer is partially structured with some linkages and lines of reasoning	1	Answer has no linkages between points and is unstructured	0	6
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Total for question 18		11																																								

Question Number	Answer	Mark
18(a)	Straight arrow at least 3.5 cm long representing horizontal force, with label F , horizontal force or 70 N	(1)
	Vector triangle drawn with at least two sides in the triangle labelled, and horizontal force on the longest side.	(1)
	All three arrows in correct relative directions (dependent on MP2)	(1)
	Magnitude = 36 N (allow an answer in the range 34 N to 38 N)	(1)
	Angle to horizontal = 30° Or 150° (allow a tolerance of $\pm 2^\circ$)	(1)
	<u>Example diagram</u> 	5