Upthrust Mark Scheme

Q1.

Question number	Answer	Additional guidance	Mark
(i)	(upthrusts in each case) are equal (1)		**(1)** **AO3**

Question number	Answer	Additional guidance	Mark
(ii)	an explanation linking any **three** of weight of ball = weight of water displaced (1) seawater more dense than fresh water (1) smaller volume of seawater (needs to be) displaced (1) to produce same weight of water (displaced) (1)	accept reverse arguments accept saltwater for seawater upthrust = weight of water displaced accept less seawater displaced to produce same upthrust	**(3)** **AO1**

Q2.

Question number	Indicative content	Mark
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **AO1 (3 marks)** • upthrust is the force on the submarine in the water (submerged) in a fluid • upthrust on the submarine and its weight act in opposite directions • upthrust is equal to the weight of water displaced by the submarine • the difference in pressures on the upper and lower surfaces of the submarine causes the upthrust **AO2 (3 marks)** • the volume of the submarine is fixed so the upthrust on the submarine is constant • increasing/decreasing volume of water in tanks increases/ decreases weight of submarine but does not affect upthrust • if weight increases to become greater than upthrust there is a resultant downward force on the submarine so the submarine sinks • if weight decreases to become less than upthrust there is a resultant upward force on the submarine so the submarine rises	**(6)**

Level	Mark	Descriptor
	0	No awardable content.
Level 1	1–2	• Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • The explanation attempts to link and apply knowledge and understanding of scientific ideas, flawed or simplistic connections made between elements in the context of the question. (AO2)
Level 2	3–4	• Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • The explanation is mostly supported through linkage and application of knowledge and understanding of scientific ideas, some logical connections made between elements in the context of the question. (AO2)
Level 3	5–6	• Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • The explanation is supported throughout by linkage and application of knowledge and understanding of scientific ideas, logical connections made between elements in the context of the question. (AO2)

Q3.

Question number	Indicative content	Mark
	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative (example) content below is not prescriptive and candidates are not required to include the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. AO2 **Pressure** • difference in pressure between top and bottom of boat • top pressure is atmospheric • pressure on bottom of boat atmospheric plus that due to depth of water. **Unloaded boat** • density of boat less than density of water • floating objects are partially immersed • floating objects displace fluid / water • upthrust is due to the difference in pressure • upthrust is equal to the weight of the boat • upthrust is equal to the weight of fluid / water displaced **Boat with load** • the weight/density of the boat increases because of the load added • more upthrust is needed to balance the extra weight of the boat • more water has to be displaced to provide the upthrust • when the boat floats lower in the water it displaces more water • the weight of water displaced is the upthrust and is equal to the weight of the boat	**(6)**

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	The explanation attempts to link and apply knowledge and understanding of scientific ideas, flawed or simplistic connections made between elements in the context of the question. Lines of reasoning are unsupported or unclear. (AO2)
Level 2	3–4	The explanation is mostly supported through linkage and application of knowledge and understanding of scientific ideas, some logical connections made between elements in the context of the question. Lines of reasoning mostly supported through the application of relevant evidence. (AO2)
Level 3	5–6	The explanation is supported throughout by linkage and application of knowledge and understanding of scientific ideas, logical connections made between elements in the context of the question. Lines of reasoning are supported by sustained application of relevant evidence. (AO2)

Level	Mark	Additional Guidance	General additional guidance – the decision within levels e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	Additional guidance Elements of physics present i.e. isolated knowledge of principles **two** unconnected statements from any section	Possible candidate responses pressure difference upthrust water displaced displacement floating
Level 2	3–4	Additional guidance Some knowledge of principles with a logical connection made in one section and statement from one other section	Possible candidate responses upthrust and weight are balanced /upthrust is equal to the weight of the boat when load added upthrust increases difference in pressure between the top and bottom of the boat
Level 3	5–6	Additional guidance Detailed knowledge of principles with logical connections made in two sections.	Possible candidate responses upthrust is equal to the weight of water displaced. when load is added, weight increases more water is displaced

Q4.

Question Number	Answer	Additional guidance	Mark
(i)	recall (1) (P =) $\frac{F}{A}$ re-arrangement and evaluation (1) A = 0.62 (m^2)	accept for recall $66\,000 = \frac{41\,000}{A}$ or $A = \frac{41\,000}{66\,000}$ allow values that round to 0.62 e.g. 0.621 award full marks for the correct answer without working	(2)

Question Number	Answer	Additional guidance	Mark
(ii)	substitution into $P = h \times \rho \times g$ (1) 66000 = h x 1000 x 10 re-arrangement and evaluation (1) (h =) 6.6 (m)	award substitution mark if it is clear that all values have been substituted ($h = \frac{66\,000}{1\,000 \times 10}$) award full marks for the correct answer without working	(2)

Question Number	Answer	Additional guidance	Mark
(iii)	An explanation linking the pressure at the bottom of the block is greater than the pressure at the top of the block (for the same area) (1) the force on the bottom is greater than the force on the top (1)	accept in terms of weight of fluid displaced the block displaces some water weight of water displaced is less than weight of (same volume) of concrete **or** water is less dense than concrete allow the upthrust (of water) is equal to the weight of the water displaced for **2** marks	(2)

Question Number	Answer	Mark
(iv)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **Between 0 and 120 seconds** • the (apparent) weight of the block is less than in air (AO2) • force in the cable is less (than weight of block) (AO3) • force remains constant because upthrust is constant (AO3) • upthrust is constant because submerged volume of block is constant (AO3) • upthrust = (17.0 – 10.2) = 6.8 kN (AO3) • lifting speed = (distance for top to reach surface / time to start to emerge) = 6.6 /120 = 0.055 m/s **Between 120 and 140 seconds** • block is emerging from water (AO3) • less volume of the block remaining submerged (AO2) • upthrust is reducing (AO3) • force in the cable is increasing (AO2) • it takes 20 seconds to fully emerge from water (AO3) • height of block = lifting speed x time for top emerge = 0.055 x 20 = 1.1 m (AO3)	(6)

	140 seconds onwards • block is clear of the water (AO3) • no upthrust (from water) on the block (AO2) • force in cable is equal to weight of block (AO2) • force is constant because weight is constant (AO2) • mass of block = weight in air / 10 = 17000 / 10 = 1700 kg (AO3) • height of lorry = lifting speed x time to reach end of lift = = 0.055 x 30 s = 1.7 m (AO3) **At all times** • (speed is constant) so no force required to accelerate the block (AO2) • so force is resultant of weight and upthrust (AO2) **Other calculations are possible, eg:** • Volume of block = height x area = 1.1 x 0.62 = 0.68 m^3 • Density of block = 1700 / 0.68= 2500 kg/m^3	

Descriptor
• No awardable content
• Interpretation and evaluation of the information attempted but will be limited with a focus on mainly just one variable. Demonstrates limited synthesis of understanding. (AO3) • The explanation attempts to link and apply knowledge and understanding of scientific ideas, flawed or simplistic connections made between elements in the context of the question. (AO2)
• Interpretation and evaluation of the information on both variables, synthesising mostly relevant understanding. (AO3) • The explanation is mostly supported through linkage and application of knowledge and understanding of scientific ideas, some logical connections made between elements in the context of the question. (AO2)
• Interpretation and evaluation of the information, demonstrating throughout the skills of synthesising relevant understanding. (AO3) • The explanation is supported throughout by linkage and application of knowledge and understanding of scientific ideas, logical connections made between elements in the context of the question. (AO2)

Summary for guidance			
Level	**Mark**	**Additional Guidance**	**General additional guidance – the decision within levels** e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	Additional guidance Isolated facts with limited quantitative work e.g. identifies the change in lifting force and gives a reason why it changes.	Possible candidate responses The lifting force increases because the block is being lifted out of the water
Level 2	3–4	Additional guidance Limited explanation that includes extracting data (from either one section of the graph or elsewhere in the question) to provide a reason why the force changes	Possible candidate responses Between 120 and 140s the lifting force increases. This is because the block is being lifted out of the water and there is less upthrust.
Level 3	5–6	Additional guidance Detailed explanation that includes calculation(s) relevant to one section of the graph and correct explanation relevant to the middle section and one other section.	Possible candidate responses When underwater, the lifting force is smaller because of upthrust from the water. The upthrust = 17-10.2 = 6.8 kN The lifting force increases after 120s because it is being lifted out of the water and the upthrust is getting smaller.