

Mark Scheme

Q1.

Question Number	Answer	Mark
	D is the correct answer A is incorrect because the addition of vector forces on an object in equilibrium = 0 B is incorrect because the addition of vector forces on an object in equilibrium = 0 C is incorrect because the addition of vector forces on an object in equilibrium = 0	1

Q2.

Question Number	Answer	Mark
	C is the correct answer A & B are incorrect because the vectors have not been added D is incorrect because the resultant is in the wrong direction	1

Q3.

Question Number	Answer	Mark
	D is the correct answer A is not the correct answer as <i>R</i> has the wrong direction B is not the correct answer as <i>R</i> has the wrong direction C is not the correct answer as <i>R</i> is along the wrong diagonal	(1)

Q4.

Question Number	Answer	Mark
	The only correct answer is B ($\frac{W}{2\sin\theta}$) A is not correct because $W = 2 \sin\theta \times \text{tension}$ C is not correct because $T \cos\theta$ is the horizontal component of tension T D is not correct because $T \cos\theta$ is the horizontal component of tension T	1

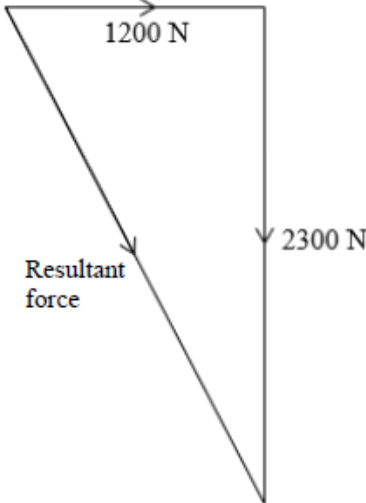
Q5.

Question Number	Answer	Mark
	The only correct answer is C ($F_A \cos(31^\circ) + F_B \cos(27^\circ)$) A is not correct because $\sin(31^\circ)$ gives a component perpendicular to the forwards direction B is not correct because $\sin(27^\circ)$ and $\sin(31^\circ)$ give components perpendicular to the forwards direction D is not correct because $\sin(27^\circ)$ gives a component perpendicular to the forwards direction	1

Q6.

Question Number	Answer	Mark
	C is the correct answer A is incorrect because R is in the wrong direction B is incorrect because R is the wrong diagonal D is incorrect because R is the wrong diagonal	(1)

Q7.

Question Number	Answer	Mark
	Correct vector triangle with arrows in correct directions. (1)	
	Resultant force = 2600 (N) (allow an answer between 2550 and 2650 N) (1)	2
	<u>Example</u> 	
	Total for question	2

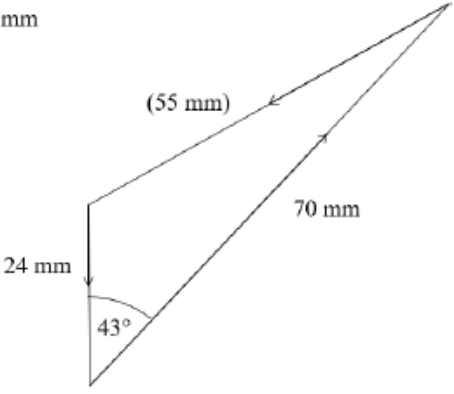
Q8.

Question Number	Answer	Mark
	The only correct answer is B ($\vec{W} + \vec{T}_1 + \vec{T}_2 = 0$) A is not correct because the vector sum of $T_1 + T_2$ is in the opposite direction to W C is not correct because T_2 should not be subtracted from T_1 D is not correct because T_2 should not be subtracted from T_1	1

Q9.

Question Number	Answer	Mark
(a)	• Use of $\Delta F = k\Delta x$ (1) • $k = 1.9 \text{ (N cm}^{-1}\text{)}$ (1) <u>Example of calculation:</u> $k = 15 \text{ N} \div 8 \text{ cm} = 1.875 \text{ N cm}^{-1}$	2
(b)	• Use of $w = mg$ (1) • Use of force triangle and Pythagoras to find F Or F resolved into components (1) • Use of trigonometry to find θ. (1) • Use of $\Delta x = \frac{\Delta F}{k}$ (1) • $\Delta x = 5.4 \text{ cm}$ (ecf from (a), "show that" value gives 5.0 cm) (1) • $\theta = 32^\circ$ (ecf from (a)) (1) <u>Example of calculation:</u> $\theta = \tan^{-1}(0.55 \text{ kg} \times 9.81 \text{ N kg}^{-1} \div 8.5 \text{ N}) = 32.4^\circ$ $\Delta x = \sqrt{((0.55 \times 9.81)^2 + 8.5^2)} \div 1.88 = 5.37 \text{ cm}$	6
	Total for question	8

Q10.

Question Number	Answer	Mark
(a)	Two arrowed lines for 70 N and 24 N with correct orientation (1) [use template for angle] Lines labelled with name/force/scaled length (1) Tension drawn in correctly i.e. correct vector diagram with correct direction (1) Answer in range 55 ± 2 N (1) 4 [Correct answer from trigonometry scores MP4 only] <u>Example of calculation</u> SCALE 1 N : 1 mm 	
(b)	Measure angle of string to vertical (1) Using a protractor (1) Calculate weight of mass holder and masses using $W = mg$ (1) Vertical component of T is equal to W (1) Vertical component is $T \cos \theta$, so T can be calculated (1) 5	
Total for question		9

Q11.

Question Number	Answer	Mark
	B is the correct answer A is not the correct answer as the magnitude of the final velocity would be greater and a little less to the right. C is not the correct answer as the final velocity would be greater and to the left of the original velocity. D is not the correct answer as the final velocity would be similar to C, but more to the left and of a lesser magnitude.	(1)

Q12.

Question Number	Answer	Mark
(a)	Vertical component of tension = $T \cos 76^\circ$ (1) Use of $650 \text{ N} = 2 \times \text{vertical component of tension}$ (1) $T = 1.34 \times 10^3 \text{ (N)}$ (1) <u>Example of calculation</u> $650 \text{ N} = 2 T \cos 76^\circ$ $T = \frac{1}{2} \times 650 \text{ N} \div \cos 76^\circ = 1\,343 \text{ N}$	3
(b)(i)	Use of $\sin 76^\circ$ or $\cos 14^\circ$ to find new length of cord (1) Use of $\varepsilon = \Delta x \div x$ (1) $\varepsilon = 0.03$ or 3% (1) <u>Example of calculation</u> $(x + \Delta x) \div 2 = 60 \text{ m} \div \sin 76^\circ = 61.8 \text{ m}$ $\Delta x = (61.8 \times 2) \text{ m} - 120.0 \text{ m} = 3.7 \text{ m}$ $\varepsilon = 3.7 \text{ m} \div 120 \text{ m} = 0.031$	3
(b)(ii)	Use of $\sigma = F \div A$ with $F = \text{tension from (a)}$ (1) Use of $E = \sigma \div \varepsilon$ (1) $E = 1.4 \times 10^8 \text{ Pa}$ (ecf from (a) and (b)(i)) (1) <u>Example of calculation</u> $\sigma = 1.34 \times 10^3 \text{ N} \div 3.14 \times 10^{-4} \text{ m}^2 = 4.28 \text{ MPa}$ $E = 4.28 \times 10^6 \text{ Pa} \div 0.031 = 1.38 \times 10^8 \text{ Pa}$	3
	Total for question	9

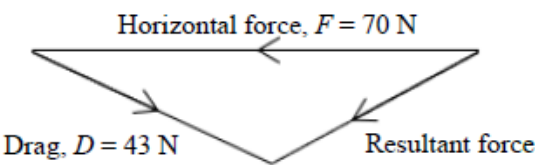
Q13.

Question Number	Answer	Mark
(a)	Upwards arrow labelled upthrust or U and downwards arrow labelled weight / W / mg (1) Arrows of equal length (1)	2
(b)(i)	Any two from - The upthrust is equal to the weight of water displaced - The upthrust equals the weight of the hydrometer - Or The upthrust is the same (in both types of water) - The weight of displaced water equals the weight of the hydrometer - Or The weight of displaced water is the same in both types of water (2) (So) a smaller volume of seawater needs to be displaced (because seawater has a greater density) (1)	3
(b)(ii)	Use of $W = mg$ (1) Use of $\rho = \frac{m}{V}$ to calculate volume of displaced water (1) Use of $V = \pi r^2 l$ (1) Subtracts position in seawater from position in pure water (1) Change in vertical position = 8 mm (1) <u>Example of calculation</u> Mass of hydrometer = $\frac{0.324 \text{ N}}{9.81 \text{ N kg}^{-1}} = 0.033 \text{ kg}$ Volume of pure water displaced = $\frac{0.033 \text{ kg}}{997 \text{ kg m}^{-3}} = 3.31 \times 10^{-5} \text{ m}^3$ Depth of hydrometer in pure water = $\frac{4 \times 3.31 \times 10^{-5} \text{ m}^3}{\pi \times (1.23 \times 10^{-2})^2} = 0.2786 \text{ m}$ Volume of seawater displaced = $\frac{0.033 \text{ kg}}{1025 \text{ kg m}^{-3}} = 3.22 \times 10^{-5} \text{ m}^3$ Depth of hydrometer in seawater = $\frac{4 \times 3.22 \times 10^{-5} \text{ m}^3}{\pi \times (1.23 \times 10^{-2})^2} = 0.2710 \text{ m}$ $\Delta L = 0.2786 \text{ m} - 0.2710 \text{ m} = 0.0076 \text{ m}$	5
Total for question		10

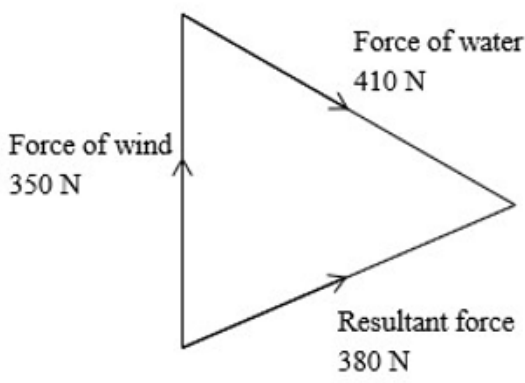
Q14.

Question Number	Answer	Mark
	A is the correct answer B is incorrect because N is in the wrong direction C is incorrect because the wrong diagonal has been used D is incorrect because the wrong diagonal has been used	1

Q15.

Question Number	Answer	Mark
(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

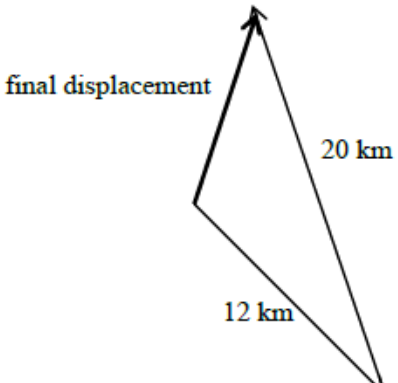
Question Number	Answer	Mark																																								
* (b)	This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows 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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5	3	2	5																																							
4	3	1	4																																							
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Total for question 18		11																																								

Question Number	Answer	Additional Guidance	Mark
	Triangle of correct shape drawn, with at least two sides labelled (1) Vector triangle drawn with at least two sides labelled and arrows in correct directions (1) Magnitude of resultant force = 380 N (1) (allow 370 N to 390 N) Angle of resultant force from north = 68° (1) (allow $66^\circ - 70^\circ$)	<u>Example diagram</u> 	4
	Total for question		4

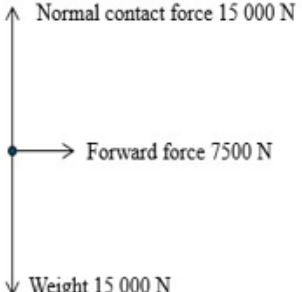
Q17.

Question Number	Answer	Mark
	B is the correct answer This is because the horizontal component is calculated using the equation $v_H = \sqrt{v^2 - v_V^2} = \sqrt{0.5^2 - 0.3^2} = 0.4$	(1)

Q18.

Question Number	Answer	Mark
	The only correct answer is B  <i>A is not the correct answer as the length and direction of the line are incorrect</i> <i>C is not the correct answer as the length and direction of the line are incorrect</i> <i>B is not the correct answer as the length and direction of the line are incorrect</i>	(1)

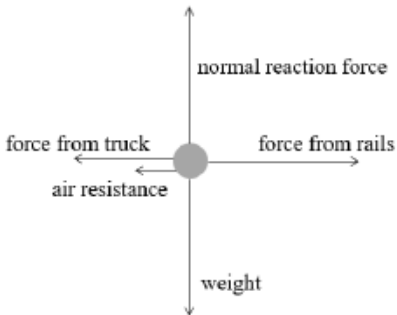
Q19.

Question Number	Answer	Additional Guidance	Mark
	Straight arrows representing forward force (F), weight (W or mg) and normal contact force (N), in correct directions with labels, all starting from dot (1) Length of weight arrow and length of normal contact force arrows equal, and twice length of forward force arrow (1)	Do not allow more than three arrows for MP1 Allow a tolerance of one small square. <u>Example of diagram</u> 	2
	Total for question		2

Q20.

Question Number	Answer	Mark
	The only correct answer is C ($90 - 49 - (5 \times 4)$) A is not correct because this gives the resultant force B is not correct because the resultant force is not zero D is not correct because this assumes that the object is accelerating downwards	1

Q21.

Question Number	Answer	Mark
(a)	Force from truck to the left [accept 1.2×10^5 (N)] (1) Air resistance to the left [accept 3.0×10^4 (N)][do not accept "viscous drag"] (1) Force from rails to the right [accept 1.5×10^5 (N)] (1) [withhold one mark if more forces than three][if magnitudes used ignore names of forces] (1) Total length of arrows towards the left equals length of arrow to the right [to within 2 mm using measuring tool][dependent on any three horizontal forces, do not check unless lengths look close by eye] 	4
(b)	A Newton's third law pair of forces - Forces of equal magnitude that act in opposite directions [do not accept "equal and opposite reaction"] [accept act for equal times] (1) - Same type of force (1) (Acting on) different bodies (1) These two forces both act on the engine [accept "on the same body"] (1) One force is gravitational [do not accept "weight"] and the other is a contact force (1)	5
Total for question		9

Q22.

Question Number	Answer	Mark
(a)	The forces act on the same object. (1) They are different types of force. (1)	2
(b)	Downward arrow labelled magnetic force (from disc) Or Downward arrow labelled F. (1) Upward arrow labelled (normal) reaction / contact / R / N / and arrow length approximately equal to $F + W$. (1) 	2
Total for question		4

Q23.

Question Number	Answer	Mark
	C is the correct answer This is because W_c should have been drawn in the centre of the cube.	(1)

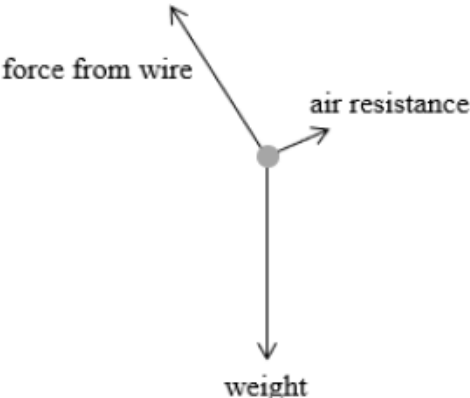
Q24.

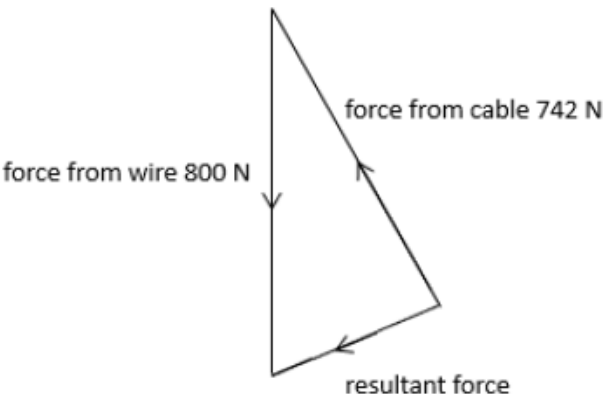
Question Number	Answer	Mark
	The only correct answer is D $\left(\sqrt{(20^2 + 35^2)}\right)$ A is not correct because the forces are not in the same direction B is not correct because the forces should each be squared before square rooting the sum of the squares C is not correct because the sum has not been square rooted	1

Q25.

Question Number	Answer	Mark
(a)(i)	Equates horizontal component with force from current (1) $F = 480 \text{ (N)}$ (1) <u>Example calculation</u> $F \sin 33^\circ = 260 \text{ N}$ $F = 260 \text{ N} \div \sin 33^\circ = 477 \text{ N}$	2
(a)(ii)	Resolves vertical component of F (1) Equates vertical forces (1) Weight of buoy = 2500 N (ecf from (a)(i)) (1) <u>Example calculation</u> $477 \text{ N} \cos 33^\circ = 400 \text{ N}$ $400 \text{ N} + \text{Weight of buoy} = 2.9 \times 10^3 \text{ N}$ $\text{Weight of buoy} = 2900 \text{ N} - 400 \text{ N} = 2500 \text{ N}$	3
(b)	EITHER Horizontal component of F increases (to maintain equilibrium) and Vertical component of F remains the same (because vertical forces do not change, upthrust and weight are constant) (1) $F^2 = F_h^2 + F_v^2$ so F increases [dependent on MP1] (1) $\tan \theta = F_h/F_v$ so θ increases [dependent on MP1] (1) OR Horizontal component of F increases (to maintain equilibrium) and Vertical component of F remains the same (because vertical forces do not change, upthrust and weight are constant) (1) $F^2 = F_h^2 + F_v^2$ so F increases [dependent on MP1] Or $\tan \theta = F_h/F_v$ so θ increases [dependent on MP1] (1) $F \cos \theta$ is constant so increase in either F or θ implies an increase in the other [dependent on MP2] (1)	3
Total for question		8

Q26.

Question Number	Answer	Mark
(a)	Arrow to the left and upwards labelled force from wire / harness (1) Arrow vertically downwards labelled weight / W / mg (1) Arrow to right (and slightly upward) labelled (viscous) drag / D or labelled air resistance (1) <u>Example diagram</u> 	3
(b)(i)	Appropriate trigonometry used (1) 742 (N) (1) <u>Example of calculation</u> $R = 2 \times 1\,200\text{ N} \times \cos(72^\circ) = 741.6\text{ N}$	2

(b)(ii)	Straight line at least 8 cm long representing force from wire (800 N), with label	(1)	4
	Vector triangle drawn with at least two sides labelled, and resultant force on shortest side	(1)	
	All 3 arrows in correct relative directions (dependent on MP2)	(1)	
	Resultant force = 400 N (Range from 390 to 410)	(1)	
	<u>Example diagram</u> 		

(c)	(most) E_{grav} transferred to E_k and mass is in both equations	(1)	3
	(So final) speed does not depend on mass of person		
	Or (So final) speed only depends on change in height		
	Or (So final) speed = $\sqrt{2g\Delta h}$ (and g is constant)	(1)	
	(assuming) work done against resistive forces is negligible	(1)	
Total for question			12