

PHYSICS



EXAM QUESTION PACK

TOPIC 15: FORCES AND MATTER

SCORE

/143

PERCENTAGE

%

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Q1.

Figure 14 shows a spring standing on a table.

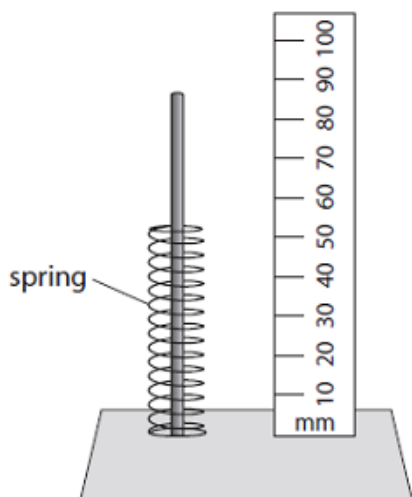


Figure 14a

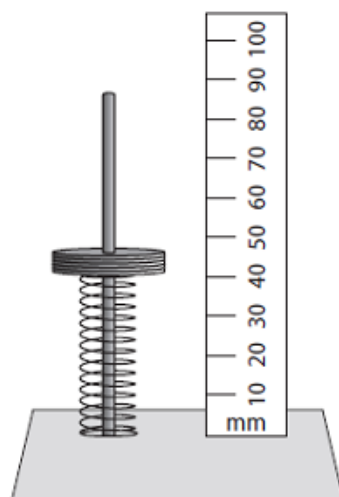


Figure 14b

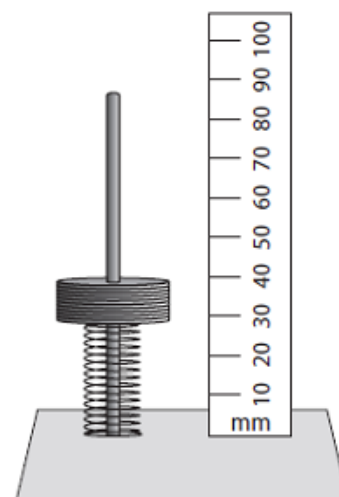


Figure 14c

Weights are added to the spring as shown in Figures 14b and 14c.

(i) Estimate the original length of the spring as shown in Figure 14a.

(1)

original length = ... mm

(ii) Describe how the reduction in the length of the spring when weights are added can be determined.

(2)

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(iii) State **two** ways that the experimental procedure could be improved.

(2)

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(iv) Give **one** reason why the reduction in length eventually reaches a limit as more weights are added.

(1)

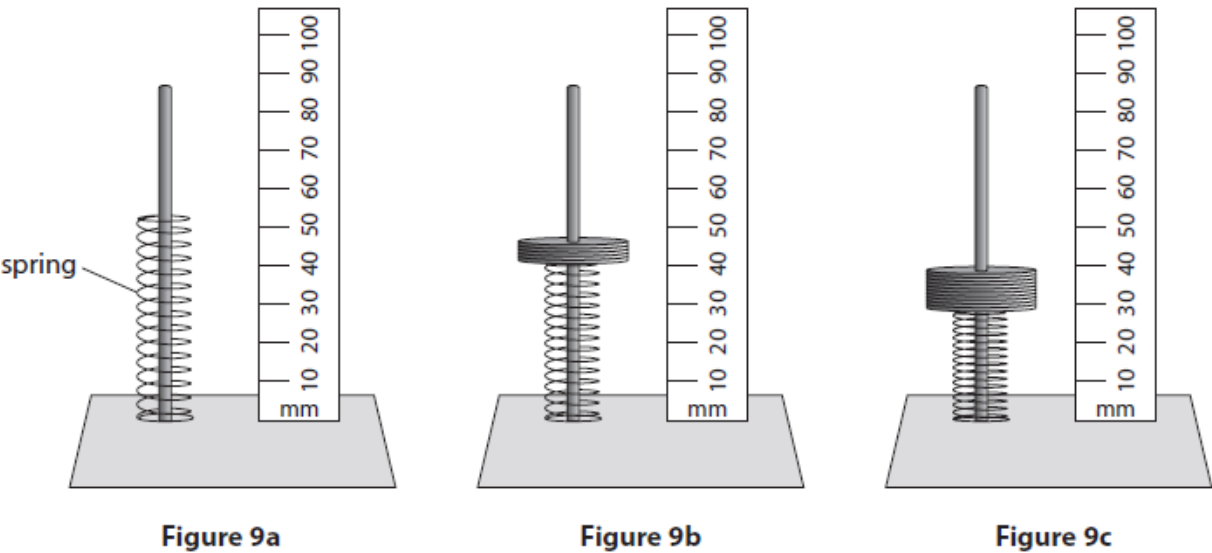
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(Total for question = 6 marks)

Q2.

Figure 9 shows a spring standing on a table.



Weights are added to the spring as shown in Figures 9b and 9c.

(i) Estimate the original length of the spring as shown in Figure 9a.

(1)

original length = ... mm

(ii) Describe how the reduction in the length of the spring when weights are added can be determined.

(2)

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(iii) State **two** ways that the experimental procedure could be improved.

(2)

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(iv) Give **one** reason why the reduction in length eventually reaches a limit as more weights are added.

(1)

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(Total for question = 6 marks)

Q3.

A student sets up the apparatus shown in Figure 9.

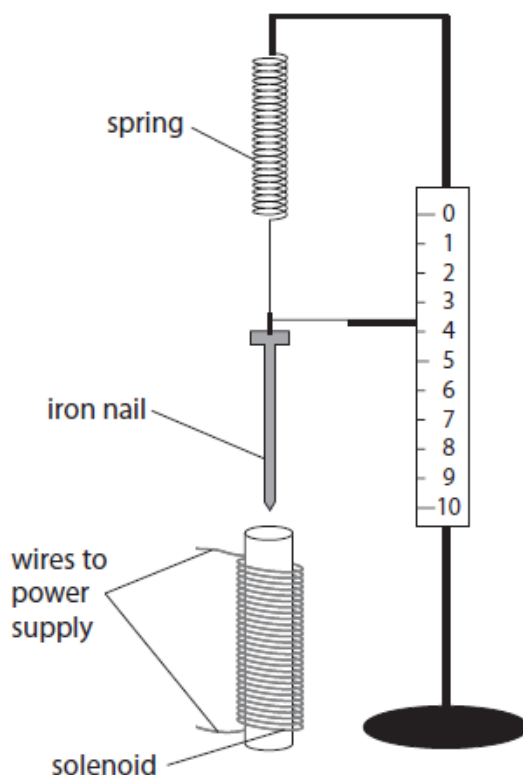


Figure 9

(i) When the current in the solenoid is switched on, the solenoid attracts the iron nail.

Describe how the student could use this apparatus to investigate how the size of the current in the solenoid affects the force of attraction between the solenoid and the iron nail.

(4)

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(ii) The spring constant of a different spring is 24 N/m.

The spring is extended from its unstretched length by 12 cm.

Calculate the energy transferred in extending the spring by 12 cm.

Use an equation selected from the list of equations at the end of this paper.

(2)

energy transferred = ... J

(Total for question = 6 marks)

Q4.

A student sets up the apparatus shown in Figure 9.

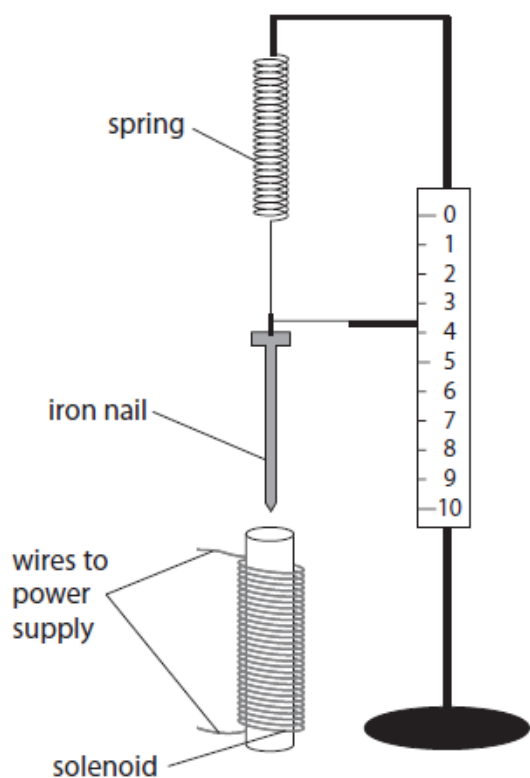


Figure 9

(i) When the current in the solenoid is switched on, the solenoid attracts the iron nail.

Describe how the student could use this apparatus to investigate how the size of the current in the solenoid affects the force of attraction between the solenoid and the iron nail.

(4)

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(ii) The spring constant of a different spring is 24 N/m.

The spring is extended from its unstretched length by 12 cm.

Calculate the energy transferred in extending the spring by 12 cm.

Use an equation selected from the list of equations at the end of this paper.

(2)

energy transferred = ... J

(Total for question = 6 marks)

Q5.

Figure 17 shows a crane lifting a concrete block from the bottom of a deep pool of water. The top of the block is a distance, h , below the surface of the water.

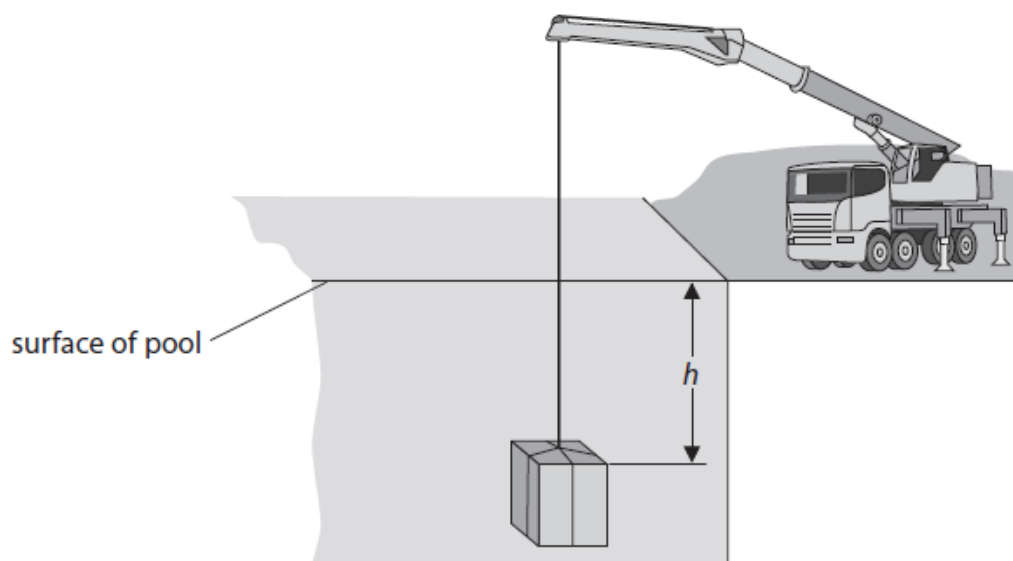


Figure 17

The force on the top of the block due to the water above it is 41 000 N.

The pressure due to the water on the top surface of the block is 66 000 Pa.

(i) Calculate the area of the top surface of the block.

(2)

area of the top surface of the block = ... m^2

(ii) The density of water is 1000 kg/m^3 .

Calculate the distance, h , between the top of the block and the surface of the water.

Gravitational field strength, g , is 10 N/kg .

Use an equation selected from the list of equations at the end of this paper.

(2)

$h = \dots\dots\dots \text{m}$

(iii) Explain why there is an upthrust produced by the water on the block.

(2)

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* (iv) The crane raises the block until it is high enough out of the water to be loaded on to a lorry.

The block moves upwards at a constant speed even though the lifting force in the cable changes.

Figure 18 shows the graph of how the lifting force changes while the block is being raised.

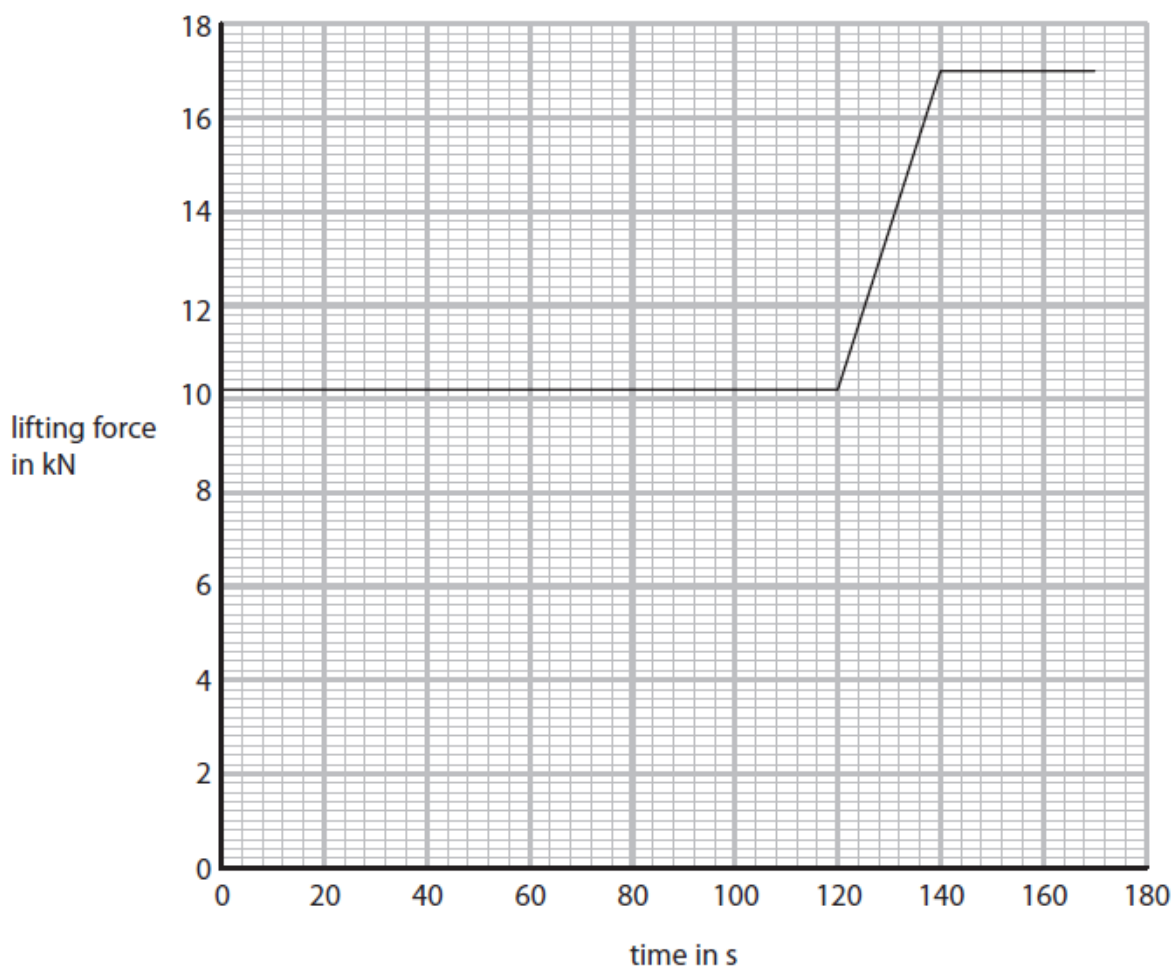


Figure 18

Explain why the lifting force changes as shown on the graph in Figure 18. Include calculation(s) in your answer.

(6)

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(Total for question = 12 marks)

Q6.

Figure 8 shows some water in a tank.



Figure 8

(i) The bottom of the tank has an area of 0.80 m^2 .

The force on the bottom of the tank, due to the water, is 2400 N.

Calculate the pressure, due to the water, on the bottom of the tank.

(3)

pressure = ... Pa

(ii) More water is added to the tank.

Explain how the pressure on the bottom of the tank changes when more water is added to the tank.

(2)

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(iii) Figure 9 shows an object on the bottom of the tank of water.

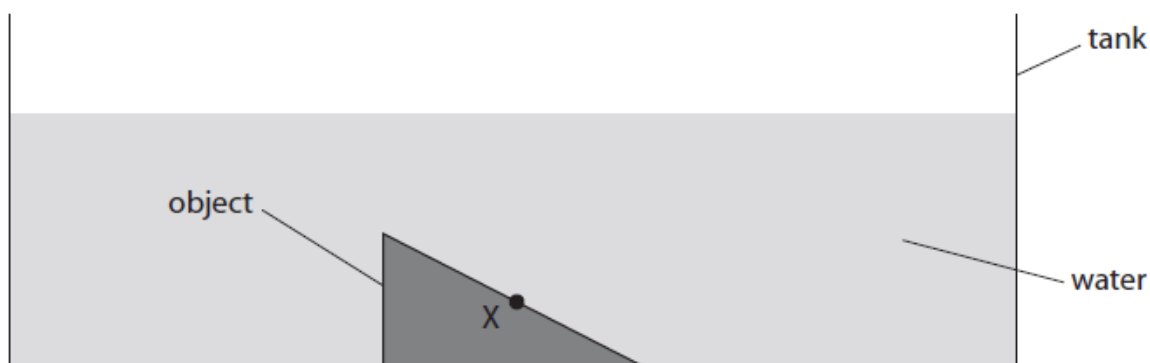


Figure 9

Draw an arrow on Figure 9 to show the direction of the force exerted by the water on the surface of the object at point X.

(1)

(Total for question = 6 marks)

Q7.

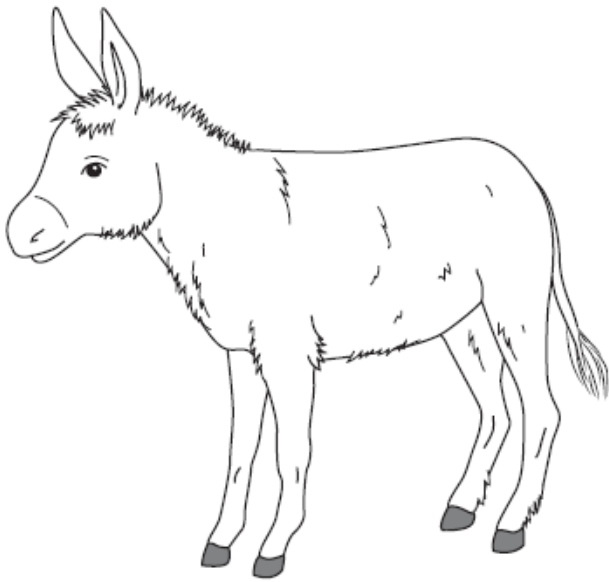


Figure 6

A donkey has a weight of 2500 N.

The area of each hoof is 0.022 m².

(i) Calculate the average pressure that the donkey exerts on the ground.

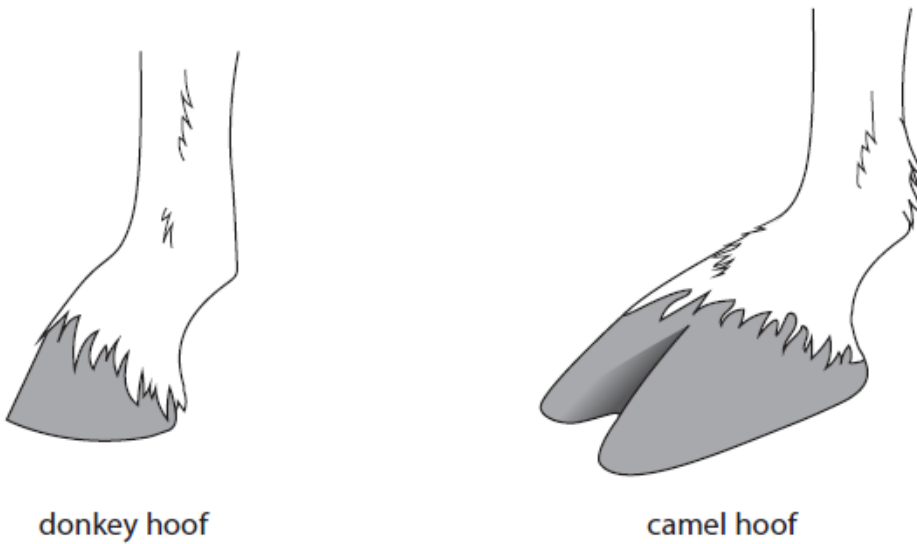
Use the equation

$$\text{pressure} = \frac{\text{force}}{\text{area}}$$

(2)

average pressure = ... Pa

(ii) Figure 7 shows how the shape of a camel's hoof is different from the shape of a donkey's hoof.



Both diagrams are drawn to the same scale.

Figure 7

The camel and the donkey have the same mass.

Explain how a camel's hoof is a more suitable shape than a donkey's hoof for walking on soft ground.

(2)

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(Total for question = 4 marks)

Q8.

Another spring is extended.

The work done to extend the spring is 0.14 J.

The spring constant of the spring is 175 N/m.

Calculate the extension of the spring.

Use an equation selected from the list of equations at the end of this paper.

(3)

extension of spring = ... m

(Total for question = 3 marks)

Q9.

Another spring is extended.

The work done to extend the spring is 0.14 J.

The spring constant of the spring is 175 N/m.

Calculate the extension of the spring.

Use an equation selected from the list of equations at the end of this paper.

(3)

extension of spring = ... m

(Total for question = 3 marks)

Q10.

Figure 26 shows a glass U-tube containing water of density 1000 kg/m^3 .

The water levels are the same on both sides of the U-tube.

Both ends of the U-tube are open to the atmosphere.

Atmospheric pressure is $101\,000 \text{ N/m}^2$.

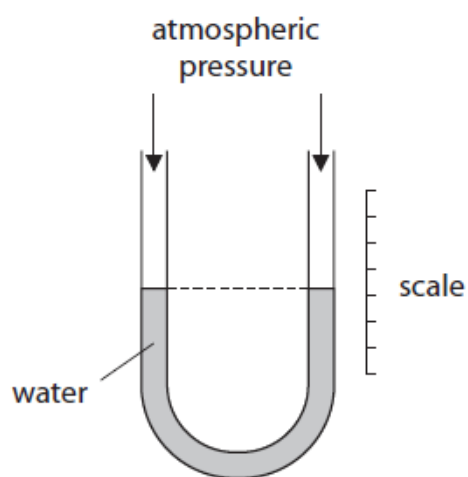


Figure 26

Figure 27 shows the U-tube with one side connected to a gas supply.

The difference in the levels of water, h , is 0.200 m.

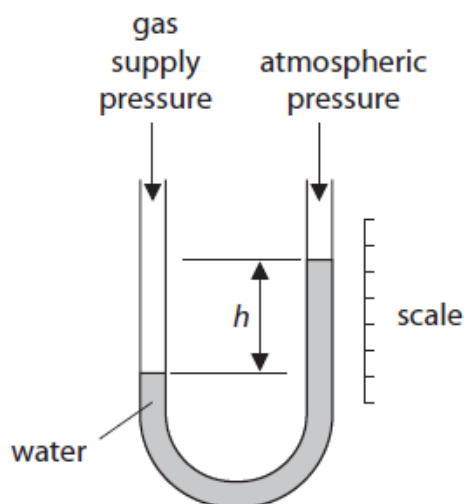


Figure 27

- (i) Calculate the gas supply pressure.
Use an equation selected from the list of equations at the end of the paper.

(3)

pressure of gas supply = ... N/m^2

- (ii) The measurement is repeated using a U-tube of larger cross-sectional area.

Explain why the value of h does not change.

(2)

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(Total for question = 5 marks)

Q11.

Figure 16 shows a beaker containing 150 g of water.



Figure 16

The cross-sectional area of the bottom of the beaker is $3.3 \times 10^{-3} \text{ m}^2$.

Calculate the pressure at the bottom of the beaker due to the water.

Take gravitational field strength, g , to be 10 N/kg .

(2)

pressure = ... Pa

(Total for question = 2 marks)

Q12.

A spring is extended.

A force of 0.50 N gives an extension of 13 mm .

Calculate the spring constant k in N/m .

(3)

spring constant k = ... N/m

(Total for question = 3 marks)

Q13.

A different spring is extended.

A force of 0.50 N gives an extension of 13 mm.

Calculate the spring constant k in N/m.

(3)

spring constant $k = \dots\dots\dots$ N/m

(Total for question = 3 marks)

Q14.

Figure 14 shows an athlete using a fitness device.

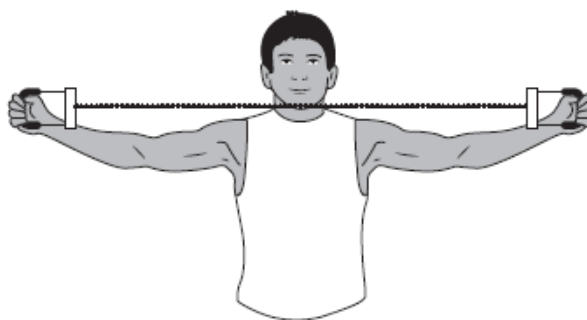


Figure 14

The athlete stretches the spring in the device by pulling the handles apart.

The spring constant of the spring is 140 N/m.

The athlete does 45 J of work to extend the spring.

The athlete takes 0.6 s to expand the spring.

(i) Calculate the useful power output of the athlete when stretching the spring.

(2)

useful power output of the athlete = ... W

(ii) Calculate the extension of the spring.

Use an equation selected from the list of equations at the end of this paper.

(3)

extension of the spring = ... m

(Total for question = 5 marks)

Q15.

Figure 7 shows an athlete using a fitness device.

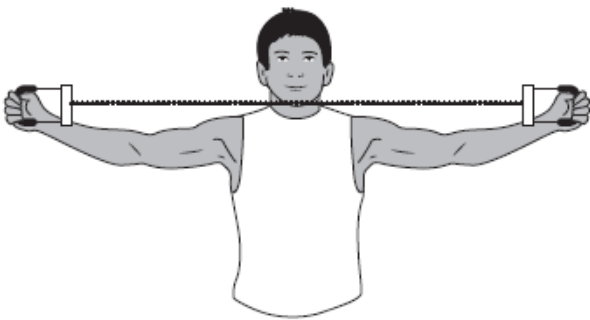


Figure 7

The athlete stretches the spring in the device by pulling the handles apart.

The spring constant of the spring is 140 N/m.

The athlete does 45 J of work to extend the spring.

The athlete takes 0.6 s to expand the spring.

(i) Calculate the useful power output of the athlete when stretching the spring.

(2)

useful power output of the athlete = ... W

(ii) Calculate the extension of the spring.

Use an equation selected from the list of equations from the relevant equation sheet.

(3)

extension of the spring = ... m

(Total for question = 5 marks)

Q16.

Figure 2 shows a tank for holding water.

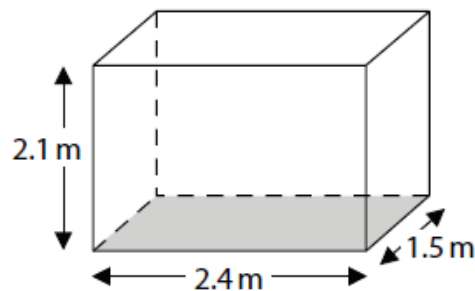


Figure 2

The tank has sides of 2.4 m, 2.1 m and 1.5 m.

The pressure at the bottom of the tank is 12 kPa.

(i) State the equation relating pressure, force and area.

(1)

(ii) Calculate the weight of water in the tank.

(4)

weight = ... N

(Total for question = 5 marks)

Q17.

A student carries out an investigation to show how pressure varies with depth in water.

A pressure sensor is attached to a rule.

The rule and pressure sensor are lowered into the water in a tank, as shown in Figure 8.

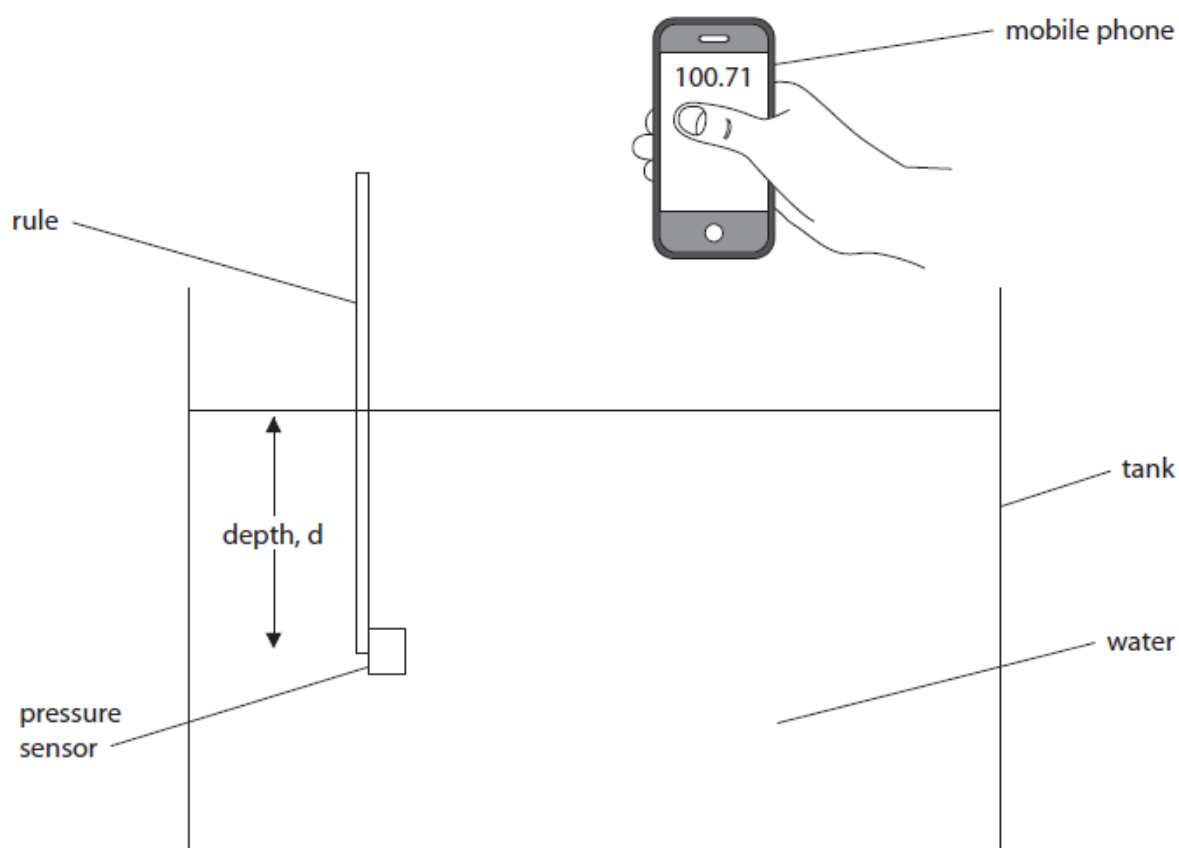


Figure 8

The depth of the pressure sensor below the surface of the water is read from the scale on the rule.

The pressure is displayed on the student's mobile phone which receives a signal from the pressure sensor.

Figure 9 gives some of the readings.

depth in m	pressure in kPa
0.050	99.15
0.100	99.70
0.150	100.15
0.200	100.70
0.250	101.15
0.300	101.70

Figure 9

Figure 10 shows a graph with some of the results plotted, but two of the points are missing.

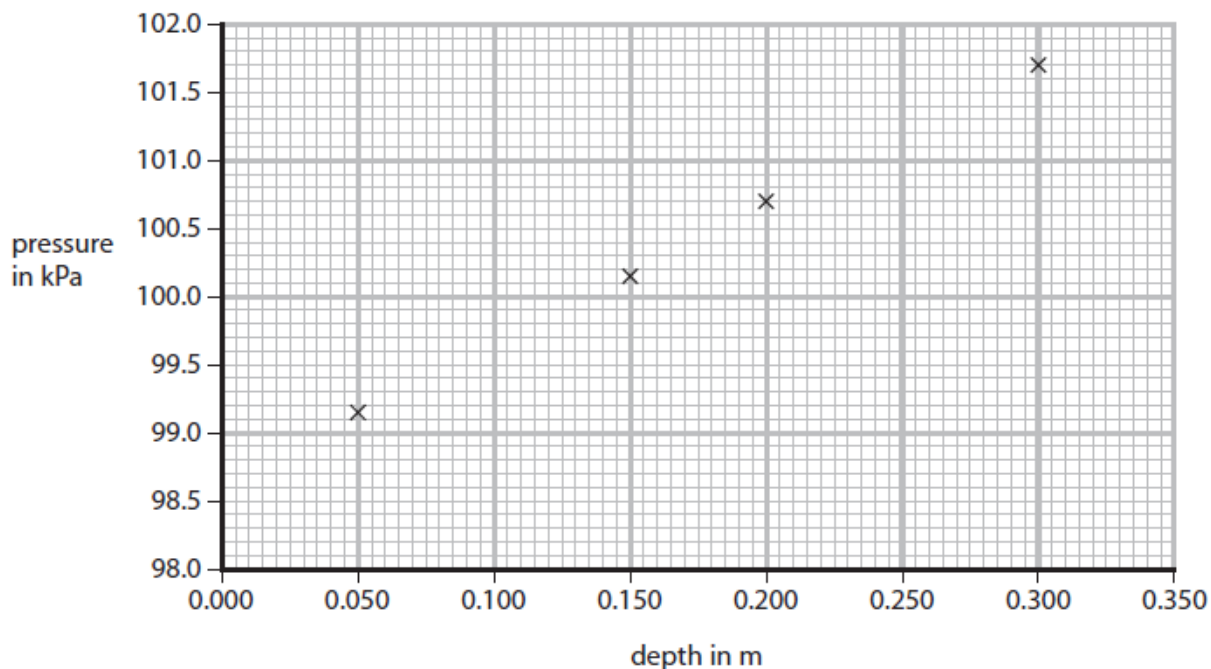


Figure 10

The student repeats the investigation using seawater and draws a graph of the results.

The seawater is more dense than the water used previously.

Compare the graph for seawater with the graph in Figure 10.

(2)

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(Total for question = 2 marks)

Q18.

Figure 17 shows information about the pressures in the ocean and in the atmosphere of a distant planet.

Graph A shows the variation of pressure as the depth in the ocean increases.

Graph B shows the variation of pressure as the height in the atmosphere increases.



Figure 17

(i) Use information from Graph A to obtain a value for the density of the ocean water.

Use an equation selected from the list of equations at the end of this paper.

(4)

density = ... kg/m³

* (ii) Explain the similarities and differences in the pressure variations shown in graphs A and B.

Your answer should refer to both the particle model (kinetic theory) and to density.

(6)

[illegible]

Q19.

A student investigates the stretching of a long piece of rubber.

Figure 15 shows the apparatus to be used.

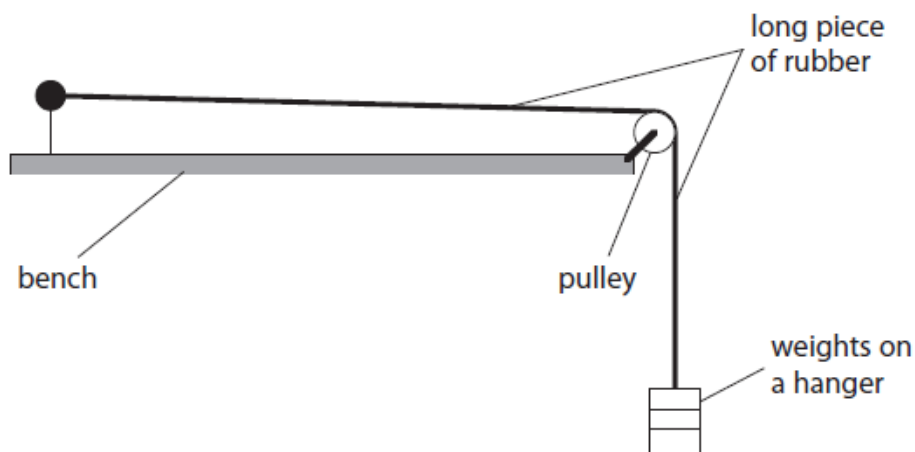


Figure 15

The student puts just enough weight on the weight hanger to make the piece of rubber just tight.

The student wants to plot a graph to show how the extension of the piece of rubber varies with the force used to stretch it.

The student adds a known weight to the weight hanger.

- (i) Describe how the student could measure the extension of the rubber when he adds another weight to the weight hanger.

(2)

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- (ii) The student obtains a series of values of force and extension while loading the piece of rubber and then unloading it.

Figure 16 shows the graph of the student's values.

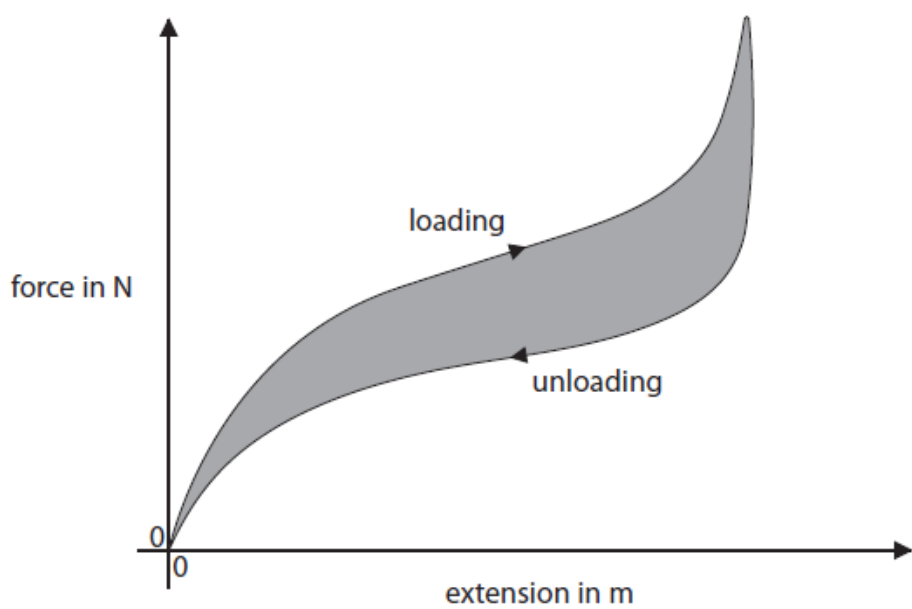


Figure 16

Explain how the shape of this graph shows that the distortion of the piece of rubber being stretched is different from the distortion of a spring being stretched.

(2)

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(Total for question = 4 marks)

Q20.

A student investigates the stretching of a long piece of rubber.

Figure 8 shows the apparatus to be used.

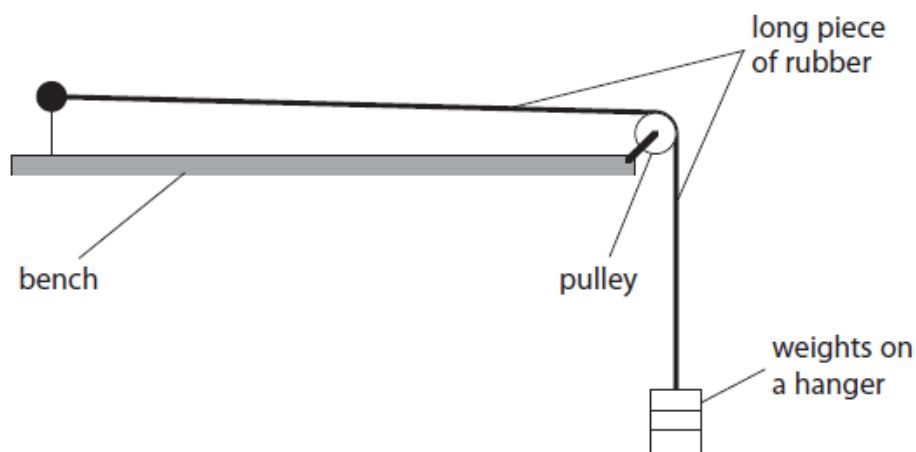


Figure 8

The student puts just enough weight on the weight hanger to make the piece of rubber just tight.

The student wants to plot a graph to show how the extension of the piece of rubber varies with the force used to stretch it.

The student adds a known weight to the weight hanger.

(i) Describe how the student could measure the extension of the rubber when he adds another weight to the weight hanger.

(2)

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(ii) The student obtains a series of values of force and extension while loading the piece of rubber and then unloading it.

Figure 9 shows the graph of the student's values.

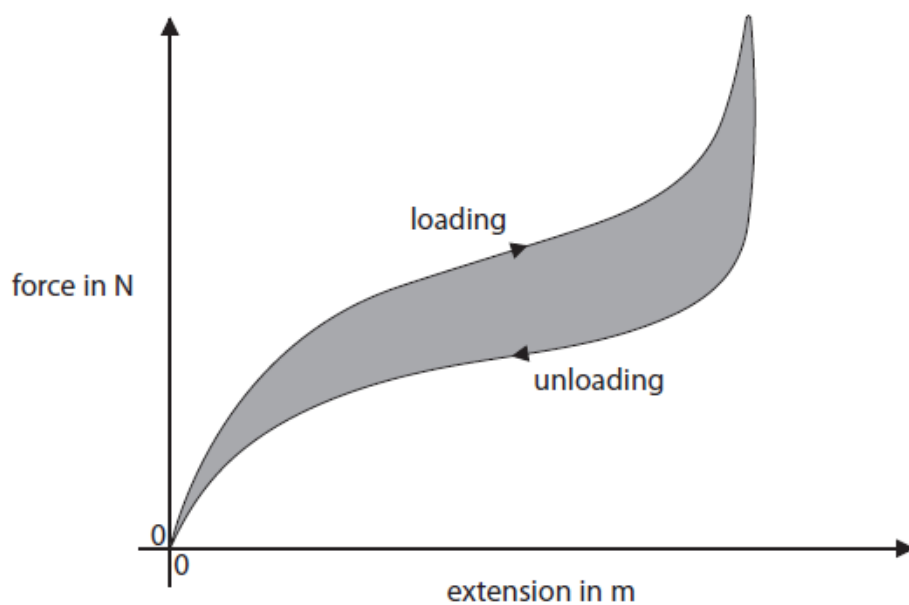


Figure 9

Explain how the shape of this graph shows that the distortion of the piece of rubber being stretched is different from the distortion of a spring being stretched.

(2)

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(Total for question = 4 marks)

Q21.

Figure 11 shows two drawings of the same person on a bed.

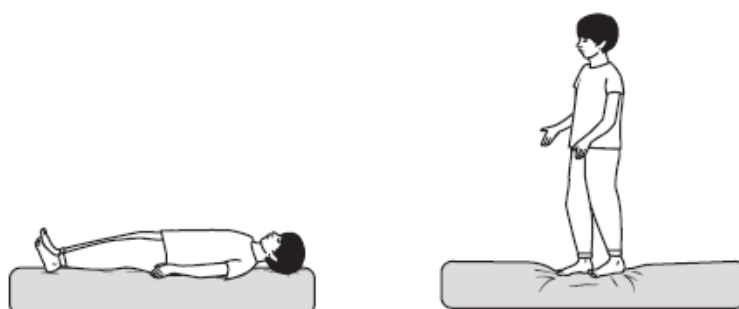


Figure 11

Explain why the person exerts a different pressure on the bed when standing up than when lying down.

(2)

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(Total for question = 2 marks)

Q22.

Figure 3 shows three containers A, B, and C.

Each container contains a liquid, as shown.

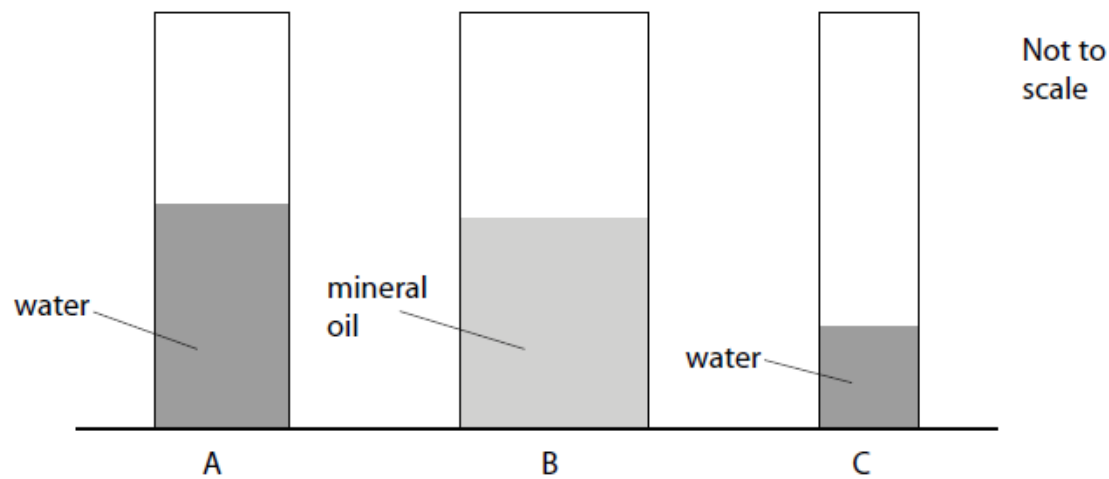


Figure 4 gives some data about the liquids and containers.

container	area of base (cm ²)	name of liquid	density of liquid (g / cm ³)	depth of liquid in container (cm)
A	16	water	1.00	50.00
B	32	mineral oil	0.91	50.00
C	12	water	1.00	25.00

Figure 4

Explain which container has the highest pressure at the bottom, and which container has the lowest.

Use information from Figure 3 and Figure 4.

(3)

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(Total for question = 3 marks)

Q23.

* Figure 26 shows the submarine stationary and submerged at a depth of 10 m.

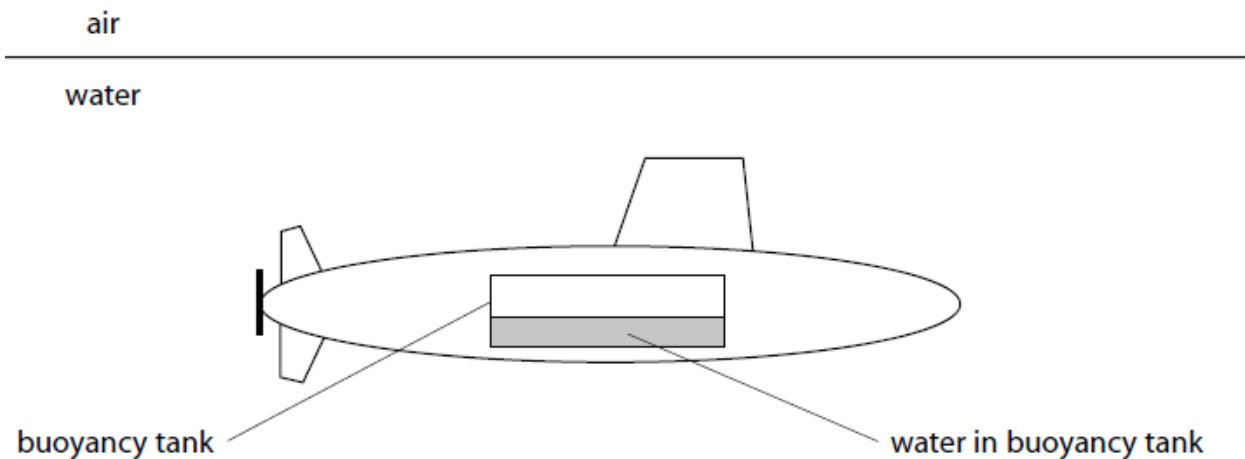


Figure 26

Explain how pumping water into and out of the buoyancy tank affects the depth of the submarine below the surface.

(6)

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(Total for question = 6 marks)

Q24.

*Figure 28 shows a cross-section of a boat floating in water and the same boat with a load inside.

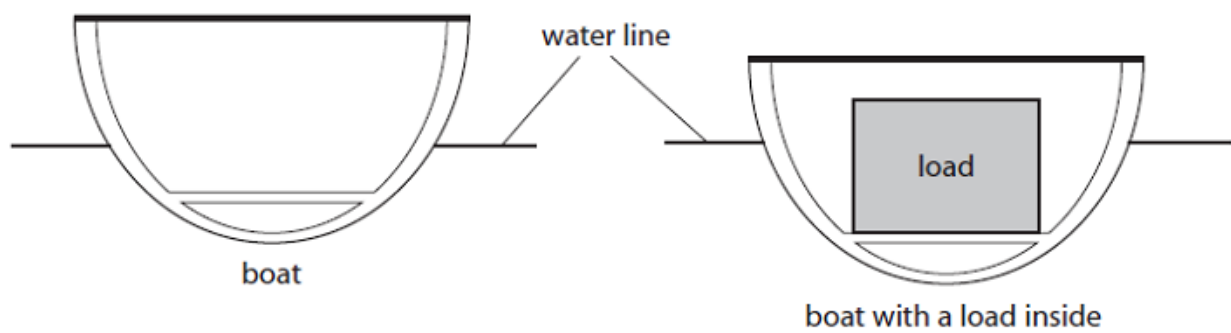


Figure 28

The boat floats lower in the water when there is a load inside the boat.

Explain why the boat floats in water and why the boat floats lower in the water when there is a load inside the boat.

You may add to the diagram to help with your answer.

(6)

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(Total for question = 6 marks)

Q25.

Figure 10 is a graph showing how the atmospheric pressure changes with the height above sea level on the Earth's surface.

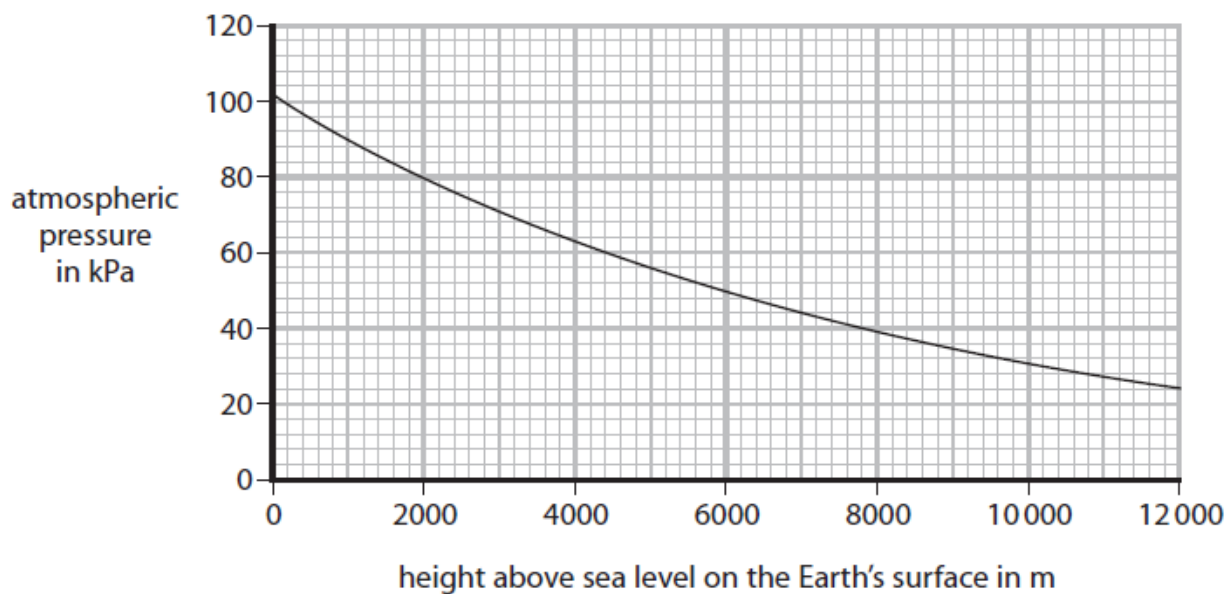


Figure 10

(i) An aeroplane descends from 6000 m to 2000 m.

Use the graph to find the change in atmospheric pressure as the aeroplane descends.

(2)

change in pressure = ... kPa

(ii) Suggest **one** reason why the atmospheric pressure is greater at 2000 m than at 6000 m.

(1)

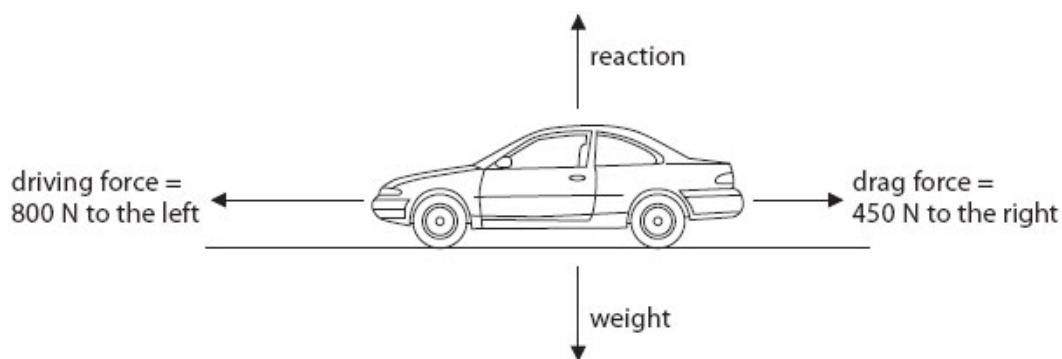
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(Total for question = 3 marks)

Q26.

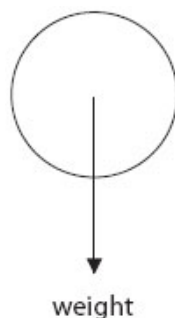
The diagram shows the forces acting on a car which is travelling along a flat straight road.



Forces also act on objects when they fall through the air.

There are two forces acting on this ball as it falls through the air.

The weight is shown on the diagram.



(i) Draw and label an arrow on the diagram to show the other force acting on the ball.

(2)

(ii) Use words from the box to complete the sentences.

(2)

balanced	changing	greater	smaller	zero
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After a short time the ball falls at a steady speed.

The forces acting on the ball are now

The acceleration of the ball is now

Q27.

Figure 13 shows a diagram of a device for lifting heavy loads.

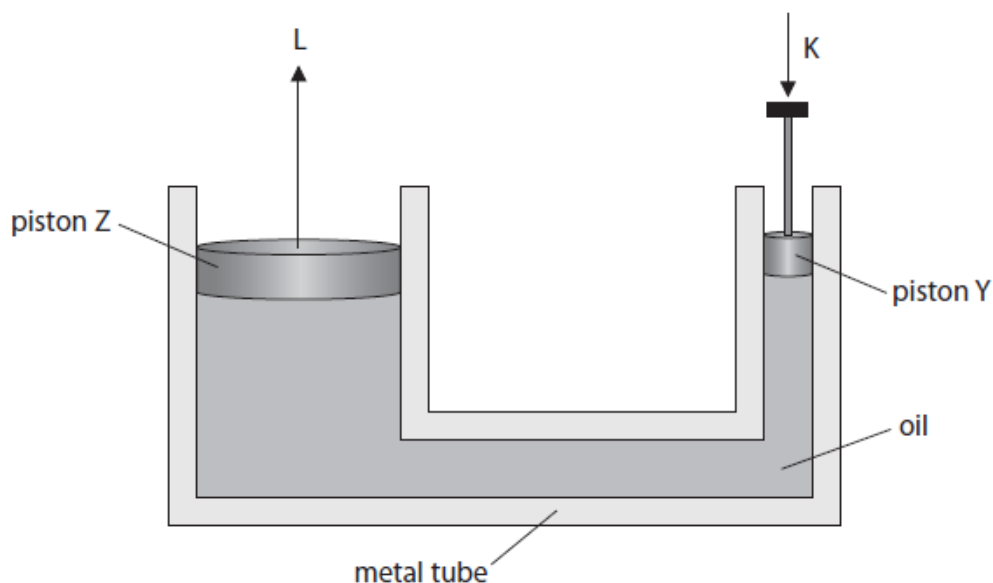


Figure 13

The metal tube is filled with oil.

The piston Y is pushed down with a force K.

This produces a force L on piston Z.

The pressure exerted on the oil by piston Y is the same as the pressure exerted by the oil on piston Z.

Explain the difference between the size of force K and the size of force L.

(3)

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(Total for question = 3 marks)

Q28.

Figure 2 shows a tank for holding water.

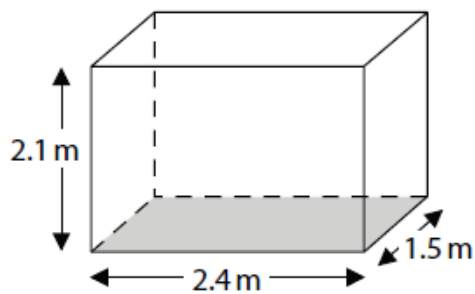
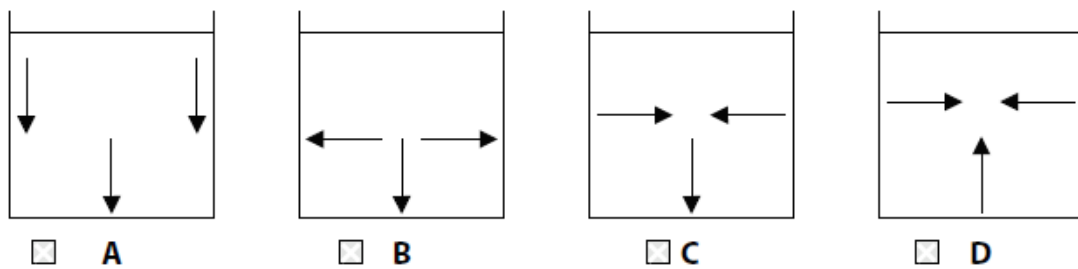


Figure 2

Which diagram shows the direction of the forces from the water on the inside of the tank?

(1)



(Total for question = 1 mark)

Q29.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

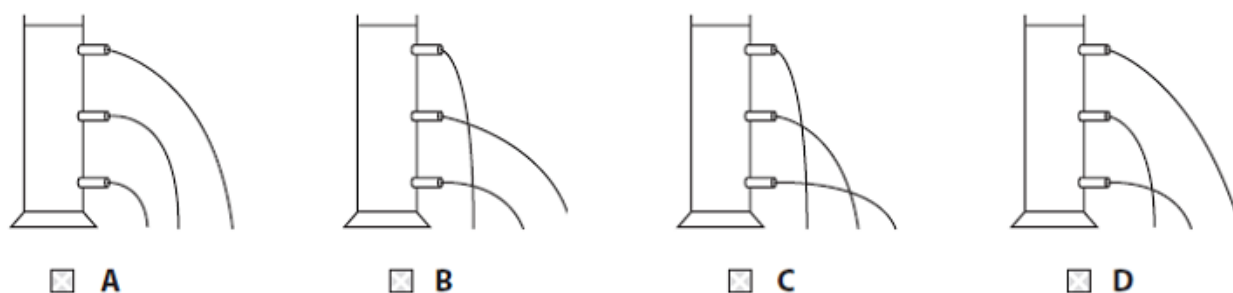
Figure 25 shows four identical metal cans, each filled with water to the same level.

Each can has three tubes.

Water comes out of each tube.

Which of these shows the correct pattern of water coming out of the tubes?

(1)



(Total for question = 1 mark)

Q30.

A student uses a digital calliper to measure the length of a spring, as shown in Figure 10.

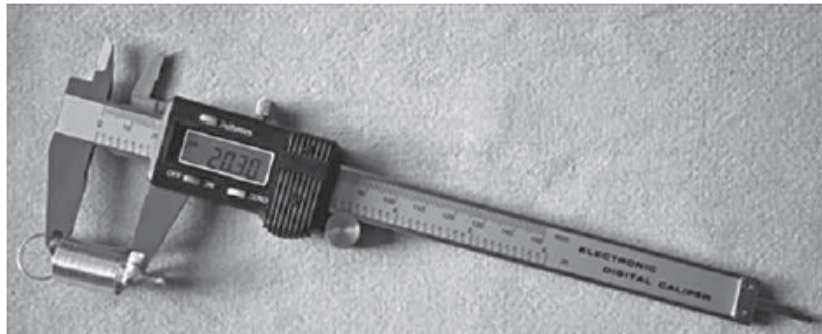


Figure 10

The spring is bendy and difficult to measure.

The student takes the six readings shown in Figure 11.



Figure 11

(a) Calculate the average length of the spring.

(2)

average length = ... mm

(b) The student investigates the stretching of a spring with the equipment shown in Figure 12.

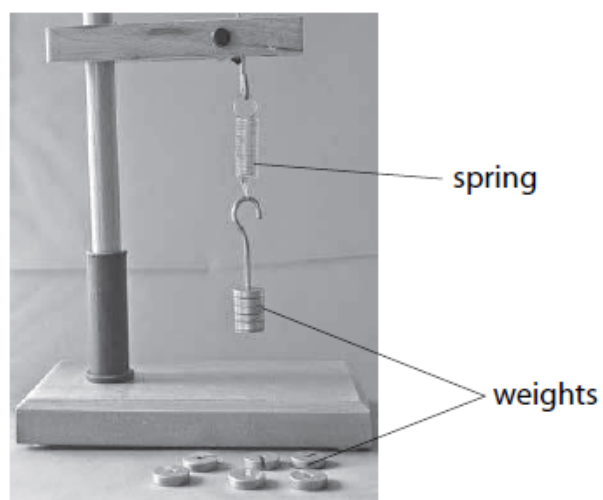


Figure 12

The student investigates the extension of the spring using six different weights.

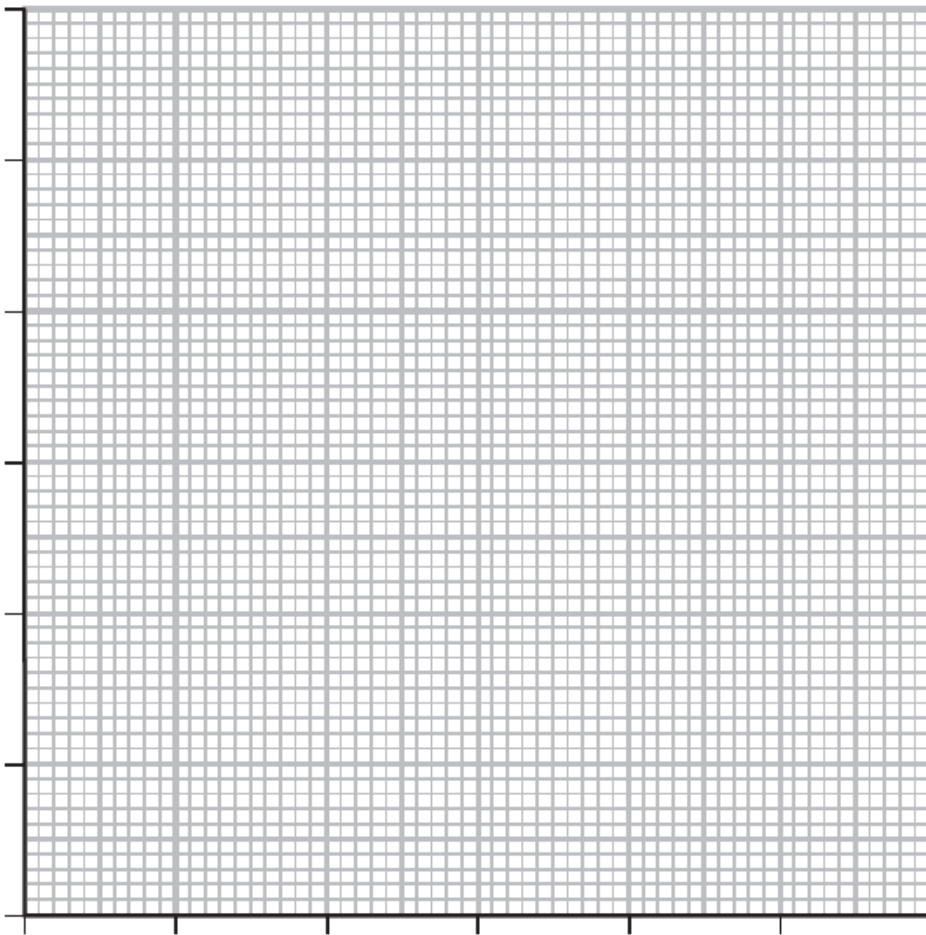
The results are shown in Figure 13.

weight (N)	extension (mm)
0.20	4.0
0.40	8.0
0.60	12.0
0.80	16.0
1.00	20.0
1.20	24.0

Figure 13

(i) Draw a graph for the readings, using the grid shown.

(3)



(ii) The student writes this conclusion:

'The extension of the spring is directly proportional to the weight stretching the spring.'

Comment on the student's conclusion.

(3)

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(c) The student extends the investigation by finding information about the stretching of wires.

The student finds the graph shown in Figure 14 for the stretching of a wire.

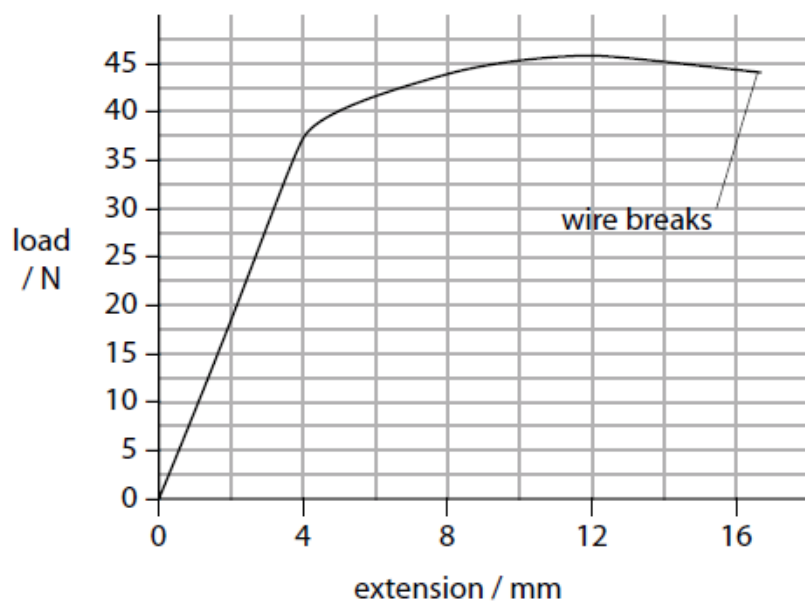


Figure 14

Describe the non-linear stretching of the wire shown in Figure 14.

(3)

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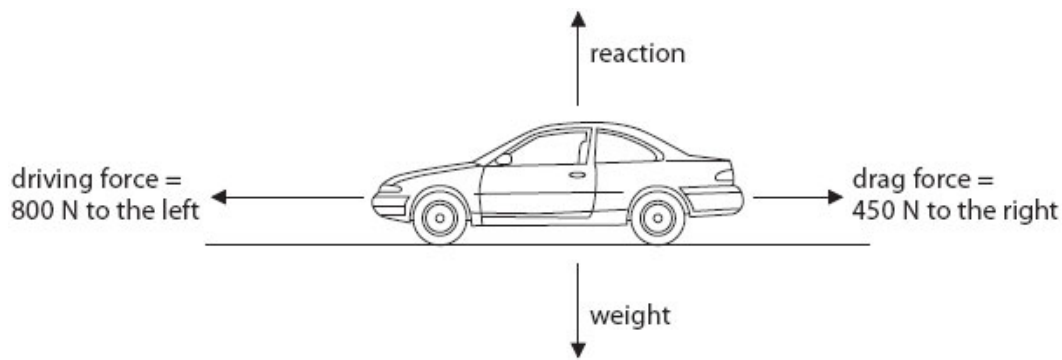
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(Total for question = 11 marks)

Q31.

The diagram shows the forces acting on a car which is travelling along a flat straight road.



(a) (i) The size of the resultant force on the car is 350 N.

In which direction is the resultant force acting?

Put a cross (☐) in the box next to your answer.

(1)

- ☒ **A** down ↓
- ☐ **B** to the left ←
- ☐ **C** to the right →
- ☐ **D** up ↑

(ii) Complete the sentence by putting a cross (☐) in the box next to your answer.

The car is

(1)

- ☐ **A** accelerating
- ☐ **B** decelerating
- ☐ **C** moving at a constant speed
- ☐ **D** not moving

(2)

(iii) The mass of the car is 625 kg.

Calculate the weight of the car.

gravitational field strength = 10N/kg

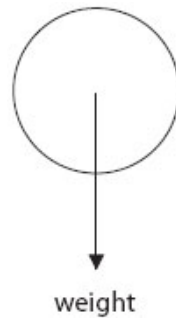
(2)

weight of car = ...N

(b) Forces also act on objects when they fall through the air.

There are two forces acting on this ball as it falls through the air.

The weight is shown on the diagram.



(i) Draw and label an arrow on the diagram to show the other force acting on the ball.

(2)

(ii) Use words from the box to complete the sentences.

(2)

balanced	changing	greater	smaller	zero
----------	----------	---------	---------	------

After a short time the ball falls at a steady speed.

The forces acting on the ball are now

The acceleration of the ball is now

(Total for Question is 8 marks)

Q32.

Some questions must be answered with a cross in a box (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

A student carries out an investigation to show how pressure varies with depth in water.

A pressure sensor is attached to a rule.

The rule and pressure sensor are lowered into the water in a tank, as shown in Figure 8.

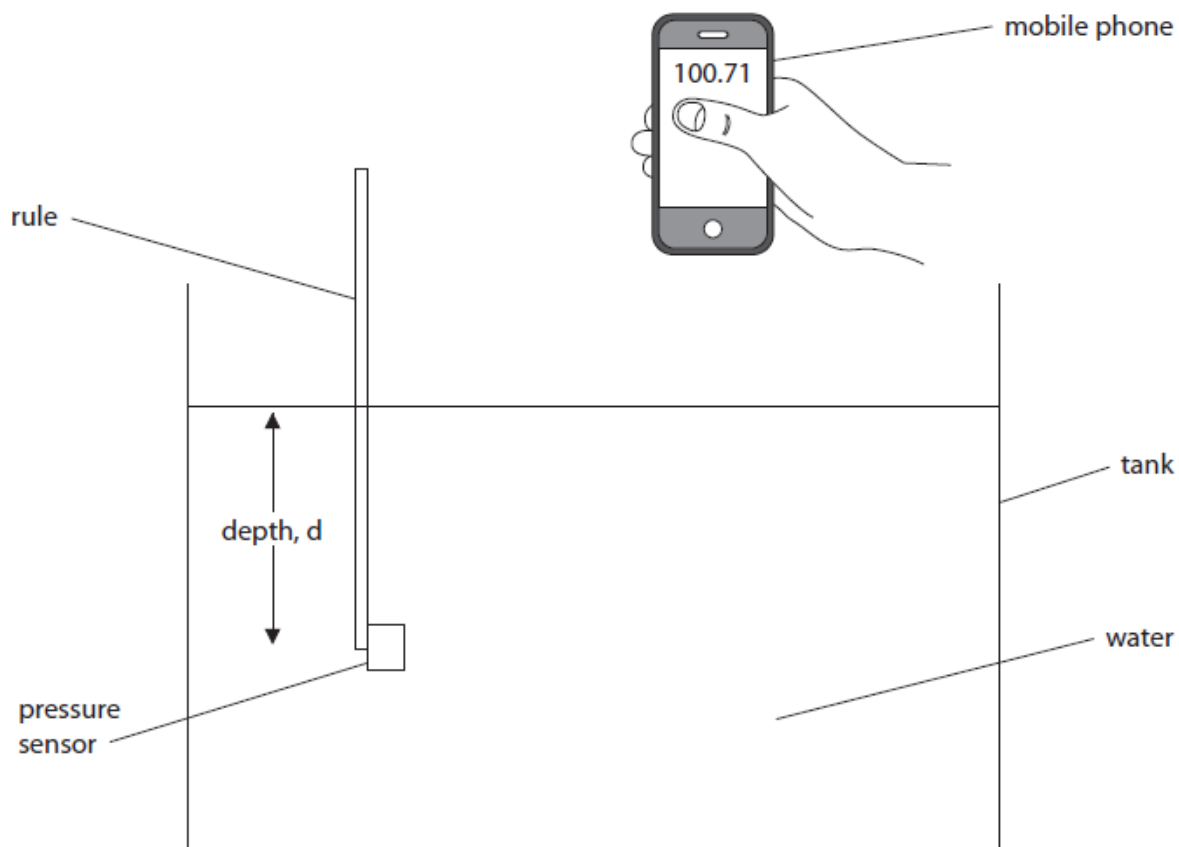


Figure 8

The depth of the pressure sensor below the surface of the water is read from the scale on the rule.

The pressure is displayed on the student's mobile phone which receives a signal from the pressure sensor.

Figure 9 gives some of the readings.

depth in m	pressure in kPa
0.050	99.15
0.100	99.70
0.150	100.15
0.200	100.70
0.250	101.15
0.300	101.70

Figure 9

Figure 10 shows a graph with some of the results plotted, but two of the points are missing.

Figure 10 shows a graph with some of the results plotted, but two of the points are missing.

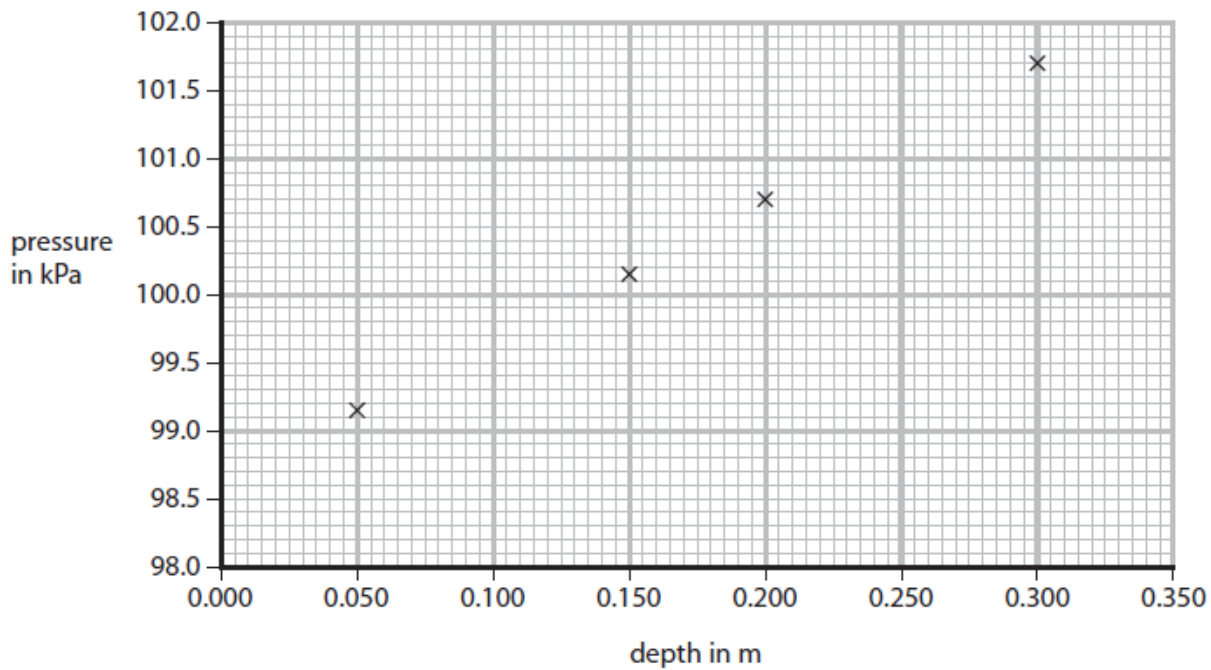


Figure 10

(i) Plot the two missing points on the graph.

(2)

(ii) Draw a line of best fit through the points on the graph.

(1)

(iii) Which of the following equations represents the variation of pressure with depth of water below the surface?

(1)

☐ **A** $y = ax^2 + b$

☐ **B** $y = mx$

☐ **C** $Y = mc - x$

☐ **D** $y = mx + c$

(iv) Use the graph in Figure 10 to predict the pressure at the surface of the water.

(1)

pressure at the surface of the sea water = ... kPa

(Total for question = 5 marks)

Q33.

A student is interested in the way that submarines are controlled.

She has several regular wooden blocks, a set of weights and a tank of water. Wood floats in water.

The student plans to immerse the wooden blocks fully in the water and investigate the relationship between the upthrust and the weight of water displaced.

Describe how she should determine **one** of the variables in this investigation.

(2)

.....

.....

.....

.....

(Total for question = 2 marks)

Mark Scheme

Q1.

Question number	Answer	Additional guidance	Mark
(i)	50.0 to 55.0 (mm) inclusive		(1)

Question number	Answer	Additional guidance	Mark
(ii)	a description including note the original length (1) note the final length and subtract (1)		(2)

Question number	Answer	Additional guidance	Mark
(iii)	any two from: use a ruler with a smaller/millimetre divisions (1) use interim values of weight (1) add more weights (to increase the range) (1) move the ruler closer to the spring (1) use of pointer (1) repeat and average (1)	ignore more accurate add fixed values of weights eye level / no parallax	(2)

Question number	Answer	Additional guidance	Mark
(iv)	the coils are {pushed together /touching} (1) or spring is fully compressed /cannot be made shorter (1)		(1)

Q2.

Question number	Answer	Additional guidance	Mark
(i)	50.0 to 55.0 mm inclusive		(1)

Question number	Answer	Additional guidance	Mark
(ii)	a description including note the original length (1) note the final length and subtract (1)		(2)

Question number	Answer	Additional guidance	Mark
(iii)	any two from: use a ruler with a smaller/millimetre divisions (1) use interim values of weight (1) add more weights (to increase the range) (1) move the ruler closer to the spring (1) use of pointer (1) repeat and average (1)	ignore more accurate add fixed values of weights eye level / no parallax	(2)

Question number	Answer	Additional guidance	Mark
(iv)	the coils are {pushed together /touching} (1) or spring is fully compressed /cannot be made shorter (1)		(1)

Q3.

Question Number:	Answer	Additional Guidance	Mark
(i)	a description to include 4 of the following: • note position of pointer before current is switched on (1) • measure position of pointer when current in coil (1) • (use an ammeter to) measure current (1) • calculate the extension / stretch of the spring (1) • use force (of attraction) is proportional to extension / stretch (of spring) (1) • repeat with different currents (1)	measure length of spring before current is switched on how far nail moves calculate force from spring constant and extension calibrate spring increase the current calculate the extension of the spring using new position of pointer minus starting position of pointer is worth 3 marks	(4) AO 2 2

Question Number:	Answer	Additional Guidance	Mark
(ii)	select and substitute (1) (E =) $\frac{1}{2} \times 24 \times 0.12^2$ evaluation (1) (E =) 0.17 (J)	$\frac{1}{2} \times 24 \times 12^2$ max 1 mark accept answers that round down to 0.17 e.g. 0.1728 POT error (e.g. 1728) max 1 mark award full marks for correct answer without working	(2) AO 2 1

Q4.

Question Number:	Answer	Additional Guidance	Mark
(i)	a description to include 4 of the following: • note position of pointer before current is switched on (1) • measure position of pointer when current in coil (1) • (use an ammeter to) measure current (1) • calculate the extension / stretch of the spring (1) • use force (of attraction) is proportional to extension / stretch (of spring) (1) • repeat with different currents (1)	measure length of spring before current is switched on how far nail moves calculate force from spring constant and extension calibrate spring increase the current calculate the extension of the spring using new position of pointer minus starting position of pointer is worth 3 marks	(4) AO 2 2

Question Number:	Answer	Additional Guidance	Mark
(ii)	select and substitute (1) (E =) $\frac{1}{2} \times 24 \times 0.12^2$ evaluation (1) (E =) 0.17 (J)	$\frac{1}{2} \times 24 \times 12^2$ max 1 mark accept answers that round down to 0.17 e.g. 0.1728 POT error (e.g. 1728) max 1 mark award full marks for correct answer without working	(2) AO 2 1

Q5.

Question Number	Answer	Additional guidance	Mark
(i)	recall (1) (P =) $\frac{F}{A}$ re-arrangement and evaluation (1) A = 0.62 (m²)	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) $66000 = h \times 1000 \times 10$ 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 = $(17.0 - 10.2) = 6.8 \text{ kN}$ (AO3) - lifting speed = (distance for top to reach surface / time to start to emerge) = $6.6 / 120 = 0.055 \text{ m/s}$ 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 = $0.055 \times 20 = 1.1 \text{ m}$ (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 = $17000 / 10 = 1700 \text{ kg}$ (AO3) - height of lorry = lifting speed x time to reach end of lift = $0.055 \times 30 \text{ s} = 1.7 \text{ m}$ (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 = $1.1 \times 0.62 = 0.68 \text{ m}^3$ - Density of block = $1700 / 0.68 = 2500 \text{ kg/m}^3$	
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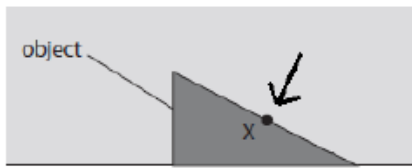
Descriptor
No awardable content
- Interpretation and evaluation of the information attempted but will be limited with a focus on mainly just one variable. Demonstrates limited synthesis of understanding. (AO3) - The explanation attempts to link and apply knowledge and understanding of scientific ideas, 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	<u>Additional guidance</u> Isolated facts with limited quantitative work e.g. identifies the change in lifting force and gives a reason why it changes.	<u>Possible candidate responses</u> The lifting force increases because the block is being lifted out of the water
Level 2	3–4	<u>Additional guidance</u> 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	<u>Possible candidate responses</u> 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	<u>Additional guidance</u> 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.	<u>Possible candidate responses</u> When underwater, the lifting force is smaller because of upthrust from the water. The upthrust = $17 - 10.2 = 6.8 \text{ kN}$ The lifting force increases after 120s because it is being lifted out of the water and the upthrust is getting smaller.

Q6.

Question number	Answer	Additional guidance	Mark
i	recall (1) $P = \frac{F}{A}$ substitution (1) $(p) = \frac{2400}{0.8}$ evaluation $(P) = 3000 \text{ (Pa)} \quad (1)$	may be implied by a correct substitution award full marks for the correct answer without working	(3) AO2

Question number	Answer	Additional guidance	Mark
ii	an explanation linking greater pressure (on bottom of tank) (1) with greater force due to water (above bottom of tank) (1)	more weight of water more depth/height of water ignore simply 'more water' or 'greater amount of water'	(2) AO1

Question number	Answer	Additional guidance	Mark
iii	 an arrow perpendicular to the sloping side and pointing towards X	judge by eye	(1) AO1

Q7.

Question number	Answer	Additional guidance	Mark
(i)	substitution (1) (pressure =) $\frac{2500}{4 \times 0.022}$ evaluation (1) 28 000 (Pa)	any number rounding to 28 000 e.g. 28 400, 28 410, 28 409 award full marks for the correct answer without working award one mark for numbers that round to 110 000 (Pa) (missing 4 in denominator) award 1 mark for 454 545 (times by 4)	(2) A02.1

Question number	Answer	Additional guidance	Mark
(ii)	An explanation linking any two from camel is less likely to sink into the soft ground (1) (same) force / weight is distributed / spread out (1) camel's hoof has greater (surface) area (than donkey) (1) camel's hoof exerts less pressure (than it would if hoof were smaller) (1)	ORA for donkey ignore pressure is spread out wider if no other marks scored then allow 1 mark for split in camel hoof enables better grip (as it walks)	(2) A03.1

Q8.

Question number	Answer	Additional guidance	Mark
	substitution (1) $0.14 = \frac{1}{2} \times 175 \times x^2$ rearrangement for x^2 (1) $(x^2 =) \frac{0.14 \times 2}{175}$ or $\frac{0.14}{0.5 \times 175}$ evaluation (1) 0.04 (m)	substitution and rearrangement in either order $x^2 = \frac{E}{\frac{1}{2} \times k}$ 1.6×10^{-3} seen gains 2 marks 0.02(m) gains 2 marks 0.028 gains 1 mark award full marks for the correct answer without working	(3)

Q9.

Question number	Answer	Additional guidance	Mark
	substitution (1) $0.14 = \frac{1}{2} \times 175 \times x^2$ rearrangement for x^2 (1) $(x^2 =) \frac{0.14 \times 2}{175}$ or $\frac{0.14}{0.5 \times 175}$ evaluation (1) 0.04 (m)	substitution and rearrangement in either order $x^2 = \frac{E}{\frac{1}{2} \times k}$ 1.6×10^{-3} seen gains 2 marks 0.02(m) gains 2 marks 0.028 gains 1 mark award full marks for the correct answer without working	(3)

Q10.

Question number	Answer	Additional guidance	Mark
(i)	substitution (1) $(p) = 1000 \times 10 \times 0.200$ evaluation of pressure difference (1) 2000 final evaluation (1) 103000 (Pa)	accept e.c.f for addition of atmospheric pressure seen for 1mark award 1 mark for selecting correct equation if no other mark awarded award full marks for correct answer without working.	(3)

Question number	Answer	Additional guidance	Mark
(ii)	an explanation linking use of $P = h \times \rho \times g$ (1) no area in the equation (1)	P /pressure, ρ /density (and g /gravitational field strength) are constant/the same Area does not affect result h /height of water is independent of area P, ρ, and g are all constant gains 2 marks	(2)

Q11.

Question number	Answer	Additional guidance	Mark
	recall and use of $P = \frac{F}{A}$ (1)	$P = \frac{0.15 \times 10}{3.3 \times 10^{-3}}$	(2)
	evaluation (1) = 450 (Pa)	454 (Pa)	

Q12.

Question number	Answer	Additional guidance	Mark
	recall and substitution (1) $0.5 = k \times 13 \times 10^{-3}$ rearrangement (1) $\frac{0.5}{13 \times 10^{-3}}$ evaluation (1) 38 (N/m)	$k = \frac{F}{x}$ allow 38.5 (N/m) or 38.46 (N/m) or 39 (N/m) 0.04/0.038 (N/m) gains 2 marks 2958 (N/m) gains 1 mark (x^2 used in equation) award full marks for the correct answer without working	(3)

Q13.

Question number	Answer	Additional guidance	Mark
	recall and substitution (1) $0.5 = k \times 13 (\times 10^{-3})$ rearrangement (1) $\frac{0.5}{13(\times 10^{-3})}$ evaluation (1) 38 (N/m)	$k = \frac{F}{x}$ allow 38.5 (N/m) or 38.46 (N/m) or 39 (N/m) 0.04/0.038 (N/m) gains 2 marks 2958 (N/m) gains 1 mark (x^2 used in equation) award full marks for the correct answer without working	(3)

Q14.

Question Number	Answer	Additional guidance	Mark
(i)	recall (1) $(P =) \frac{E}{t}$ substitution and evaluation (1) (P=) 75 (W)	P = work done ÷ time $P = \frac{45}{0.6}$ award full marks for the correct answer without working	(2)

Question Number	Answer	Additional guidance	Mark
(ii)	substitution into $E = \frac{1}{2} \times k \times x^2$ (1) $45 = \frac{1}{2} \times 140 \times x^2$ rearrangement (1) $(x =) \sqrt{\frac{2 \times 45}{140}}$ evaluation (1) 0.8(0) (m)	allow substitution and rearrangement in either order $x^2 = (\frac{E}{0.5k} =) \frac{2 \times 45}{140}$ $x^2 = 0.64(28571)$ accept values that round to 0.80 e.g. 0.80178 award full marks for the correct answer without working	(3)

Q15.

Question Number	Answer	Additional guidance	Mark
(i)	recall (1) $(P =) \frac{E}{t}$ substitution and evaluation (1) (P=) 75 (W)	$P = \text{work done} \div \text{time}$ $P = \frac{45}{0.6}$ award full marks for the correct answer without working	(2)

Question Number	Answer	Additional guidance	Mark
(ii)	substitution into $E = \frac{1}{2} \times k \times x^2$ (1) $45 = \frac{1}{2} \times 140 \times x^2$ rearrangement (1) $(x =) \sqrt{\frac{2 \times 45}{140}}$ evaluation (1) 0.8(0) (m)	allow substitution and rearrangement in either order $x^2 = (\frac{E}{0.5k} =) \frac{2 \times 45}{140}$ $x^2 = 0.64(28571)$ accept values that round to 0.80 e.g. 0.80178 award full marks for the correct answer without working	(3)

Q16.

Question number	Answer	Mark
(i)	pressure = force ÷ area	(1)

Question number	Answer	Additional guidance	Mark
(ii)	rearrangement (1) $(F =) P \times A$ calculation of area (1) $2.4 \times 1.5 = 3.6$ substitution (1) $(F =) 12\,000 \times 3.6$ answer (1) 43 200 (N)	award full marks for correct numerical answer without working maximum 3 marks if kPa not converted to Pa	(4)

Q17.

Question number	Answer	Additional guidance	Mark
	any two from pressure(s) would be greater (values) (1) steeper gradient of graph (1) both straight lines (1) intercept (on pressure axis) the same (1)	credit mark points seen on graph bigger gradient / steeper line (of best fit) both linear pressure at surface is the same	(2) A03.2

Q18.

Question number	Answer	Additional guidance	Mark
(i)	rearrange $p = \rho g h$ to give $\rho = p / (g h)$ (1) substitution using any point from graph (1) e.g. depth = 50km and pressure = 1.5 GPa $\rho = p / (g h)$ $= 1.5 \times 10^9 / (10 \times 50 \times 10^3)$ Evaluation (2) $= 3000 \text{ (kg/m}^3\text{)}$	rearrangement and substitution in any order allow any combination from the graph and ignore 'pot' error here 'pot' error scores 2 marks maximum	(4)

Question number	Indicative content	Mark
(ii)	Answers will be credited according to the 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 of the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. A02 (3 marks) A03 (3 marks) A03 Interpretation and evaluation from the graph Similarities: • both show increasing pressure with depth • both show a range of pressures over kilometre depths / heights Differences: • ocean water shows a linear relationship (straight line) but atmosphere gives a non-linear (curved) relationship • density of ocean water not changing with depth but density of atmosphere changes as you go higher • The pressures in the ocean recorded are much bigger (GPa compared with kPa) The depth of the ocean shown is up to 100km whereas the height of the atmosphere involved is only up to 10km A02 Link between graph shapes and underlying physics Similarities: • pressure is due to (increasing) weight of fluid (liquid / gas) above • more molecules above Differences: • atmosphere becomes thinner the higher you go molecules in the ocean stay (on average) the same distance apart but in the atmosphere they get further apart (on average) as you go higher up	(6)

Level	Mark	Descriptor
	0	No awardable content
Level 1	1–2	- 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)
Level 2	3–4	- 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)
Level 3	5–6	- 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)

Q19.

Question Number	Answer	Additional guidance	Mark
(i)	A description including any one from the following (1) measure a length or a specific distance related to the rubber or weights on a hanger OR with a named device (e.g. metre rule / stick / ruler / measuring tape) OR note position of a fixed point on rubber / weight carrier AND extension calculated / measured as the change in or difference between two positions or lengths or extensions (1)	evidence may be taken from additions to the diagram ignore vague statements such as see how it much it extends	(2)

Question Number	Answer	Additional guidance	Mark
(ii)	An explanation linking graph of rubber band is non-linear / curved / not directly proportional (1) graph for unloading does not go through same points as loading (1)	(graph for) spring would be straight (graph for) spring would only have one line / go through the same points ignore reference to returning to original shape / length	(2)

Question Number	Answer	Additional guidance	Mark
(i)	A description including any one from the following (1) measure a length or a specific distance related to the rubber or weights on a hanger OR with a named device (e.g. metre rule / stick / ruler / measuring tape) OR note position of a fixed point on rubber / weight carrier AND extension calculated / measured as the change in or difference between two positions or lengths or extensions (1)	evidence may be taken from additions to the diagram ignore vague statements such as see how it much it extends	(2)

Question Number	Answer	Additional guidance	Mark
(ii)	An explanation linking graph of rubber band is non-linear / curved / not directly proportional (1) graph for unloading does not go through same points as loading (1)	(graph for) spring would be straight (graph for) spring would only have one line / go through the same points ignore reference to returning to original shape / length	(2)

Q21.

Question number	Answer	Additional guidance	Mark
	an explanation linking the area (of contact between person and bed) is smaller when standing up (1) same weight (over smaller area) so the pressure is greater when standing up (1)	accept reverse arguments weight is more concentrated / not distributed /not spread across bed (when standing up) uses $p = F/A$ argument (as a consequence of the smaller area, pressure is bigger)	(2) AO2

Q22.

Question number	Answer	Additional guidance	Mark
	An explanation that combines identification via a judgement (1 mark) to reach a conclusion via justification/reasoning (2 marks): • pressure in A is the highest and pressure in C is the lowest (pressure in B is between them) (1) • pressure depends on depth of liquid (so) can compare A and C because same liquid (hence) pressure in A is twice that of C (1) • pressure depends on density of liquid (so) can compare A and B since same depth hence pressure in A greater than pressure in B (1)	allow a mathematical approach, i.e. calculating all three pressures from the relevant data	(3)

Q23.

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)

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	<u>Additional guidance</u> Elements of physics present i.e. isolated knowledge of principles two unconnected statements from any section	<u>Possible candidate responses</u> pressure difference upthrust water displaced displacement floating
Level 2	3–4	<u>Additional guidance</u> Some knowledge of principles with a logical connection made in one section and statement from one other section	<u>Possible candidate responses</u> 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	<u>Additional guidance</u> Detailed knowledge of principles with logical connections made in two sections.	<u>Possible candidate responses</u> upthrust is equal to the weight of water displaced. when load is added, weight increases more water is displaced

Q25.

Question number	Answer	Additional guidance	Mark
i	data points correctly identified (1) 50 $\pm$ 2 80 $\pm$ 2 evaluation (1) (-)30 $\pm$ 4 kPa	award 1 mark if 80 and 50 seen ignore the lack of minus sign allow ecf from incorrect reading of either pressure at 2000m or pressure at 6000m for one mark	(2) AO3

Question number	Answer	Additional guidance	Mark
	any one suggestion of greater density of atmosphere (1) greater depth of atmosphere (above the aeroplane) (1) greater temperature (of the atmosphere) (1)	accept reverse argument more particles (per cubic metre) the air gets thicker greater weight of the atmosphere	(1) AO1

Q26.

	Answer	Acceptable answers	Mark
(i)	 air resistance (1)	upward arrow on any part of line vertical line from any point on the diagram (1) air friction, upthrust, drag Ignore any downward arrow labelled weight or gravity	(2)
(ii)	Balanced (1) Zero (1)		(2)

Q27.

Question Number:	Answer	Additional Guidance	Mark
	an explanation linking: use of $P = \frac{F}{A}$ (1) area of piston Y is less than area of piston Z (1) (therefore) force K is less than force L (1)	accept answers in terms of work = force x distance accept reverse arguments accept K for piston Y and L for piston Z	(3) AO 3 2a AO 3 2b

Q28.

Question number	Answer	Mark
	B	(1)

Q29.

Question number	Answer	Mark
	C  A,B and D are incorrect because pressure increases with depth	(1)

Q30.

Question number	Answer	Additional guidance	Mark
(a)	evidence that anomalous reading excluded (1) evaluation (1) average length = 20.31 (mm)	accept 101.57 ($\div 5$) for first mark accept 20.314 (mm)	(2)

Question number	Answer	Additional guidance	Mark
(b)(i)	• Axes with linear scales that use more than half of each edge of the grid and labelled with units from table (1) • All points correctly plotted to $\pm$ half a square (1) • Single straight line passing through all points and the origin (1)	allow 1 mark if only one plotting error and correct line drawn for points plotted	(3)

Question number	Answer	Additional guidance	Mark
(b)(ii)	A comment that makes reference to the following points: (using table) • idea that equal increments of force/weight/mass cause equal increments of extension (1) • correct reference to figures in the table (1) OR (using graph) • the graph line is straight (1) • the graph line passes through the origin (1) AND therefore the student's conclusion is correct (1)	last marking point can only be achieved if at least one of the other two marks is awarded	(3)

Question number	Answer	Additional guidance	Mark
(c)	An answer that combines points of interpretation/evaluation to provide a logical description: - above 37.5 N/4 mm there are large increases of extension for small increases in load (1) - the maximum extension of the wire is about 16.5 mm before it breaks (1) - above 12 mm the wire keeps on extending when the load is reduced below 46 N (1)	accept extension is (much) greater for each 1 N increase in load above 37.5 N	(3)

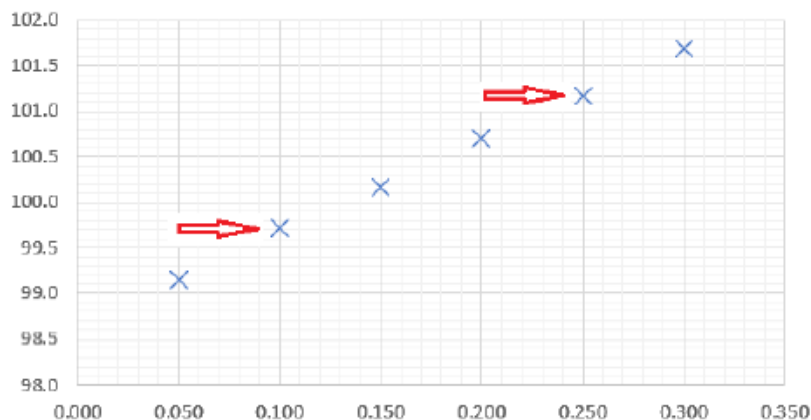
Q31.

	Answer	Acceptable answers	Mark
(a)(i)	B to the left ←		(1)
(a)(ii)	A accelerating		(1)
(a)(iii)	substitution 625x 10 (1) Evaluation 6250 (N) (1)	625 x 9.8 6125 (N) give full marks for correct answer, no working	(2)
(b)(i)	 air resistance (1)	(1) upward arrow on any part of line vertical line from any point on the diagram air friction, upthrust, drag Ignore any downward arrow labelled weight or gravity	(2)
(b)(ii)	Balanced (1) Zero (1)		(2)

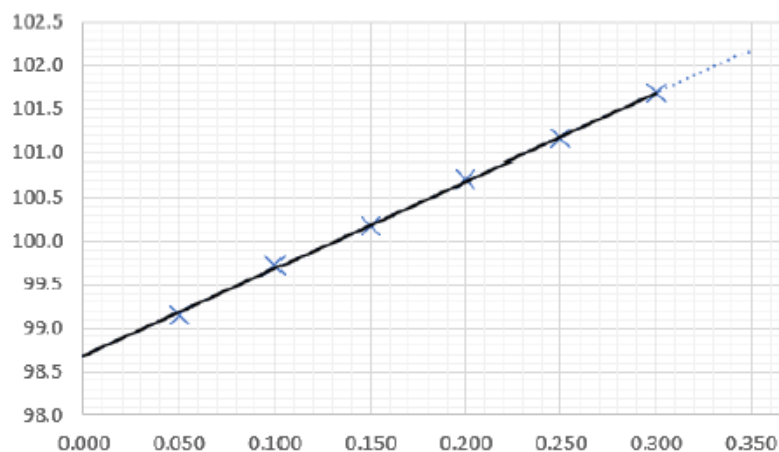
Total for marks for question = 8

Q32.

Question number	Answer	Additional guidance	Mark
(i)	points plotted to within ± 1 small square (0.100, 99.7) (1) (0.250, 101.15) (1)		(2) AO2.1



Question number	Answer	Additional guidance	Mark
(ii)	best fit straight line passing through at least four of the points (1)	do not accept tramlining (multiple lines / curves) ignore slight shakiness in drawing	(1) AO2.1



Question number	Answer	Mark
(iii)	$y = mx + c$ Figure 10 shows a linear graph with a positive gradient and intercept	(1) AO1.1

Question number	Answer	Additional guidance	Mark
(iv)	answer between 98.6 and 98.8 (kPa)	allow ecf from their line of best fit in b(ii)	(1) AO3.2

Q33.

Question number	Answer	Mark
	An answer that combines the following points to provide a logical description of the plan: EITHER • (determine upthrust) by adding weights until the block of wood is fully immersed and recording the load required (1) • calculate upthrust by adding load and weight of block (1) OR • (determine the weight of water displaced) by using a ruler to measure the dimensions of the block and multiplying them together to find the volume (1) • calculate the weight of water from $\text{volume} \times \text{density} \times g$ (1)	(2)