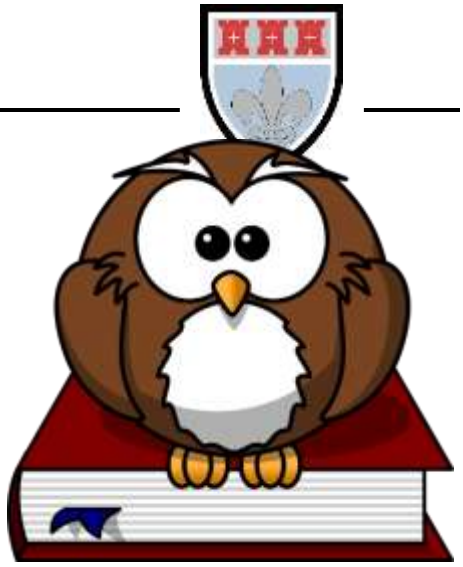

MECHANICS

A LEVEL PHYSICS

EXAMINATION PREPARATION BOOK

STUDENT BOOK

TOPIC BOOK

NAME	
PHYSICS CLASS	
MODULE TEACHER	
ALPS GRADE	

Please complete all of these questions in this book and store this work in your student files.

This will provide a useful resource for revision.

In the following booklet there are several questions based on the module '3.4 Mechanics and Materials'. These questions are additional to the work which you must do on your A-Level course.

To gain the highest grade possible in your A-Level examinations it is recommended that you complete these questions in the supervised study sessions carried out in school.

This will both familiarise yourself with both the concepts found in the A-Level syllabus and the examination technique found in examinations.

The mark scheme to the questions is integrated in the book for you to use independently.

To improve competency in answering questions on mechanics and materials and achieve mastery in this module, answer all of these questions independently.

When you have completed your work in this book, please store this work in your student files.

Many thanks for all of your hard work in A-Level Physics.

Mr. Turnbull

QUESTION ONE

1.1 Calculate the weight of an ice cube that has volume 4.0×10^{-6} m^3

Density of ice = 920 kg m^{-3}

[2 marks]

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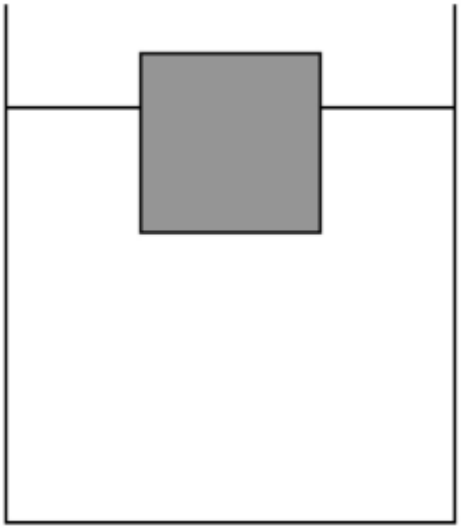
Weight =..... N

1.2 Figure 5 shows the ice cube floating in a beaker of water.

Figure 5



When the ice cube is placed in the beaker, it displaces a volume of water causing the water level to rise.

The weight of water displaced is equal to the weight of the ice cube.

Calculate the volume of water displaced by the ice cube.

Density of water = 1000 kg m^{-3}

[1 mark]

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.....

Volume =..... m^3

1.3 The ice cube in **Figure 5** is replaced by another cube also with volume 4.0×10^{-6} m^3

This cube is made of ice containing a small piece of iron.

The mass of water now displaced is 3.9×10^{-3} kg

Calculate the volume of the piece of iron.

Density of iron = 7800 kg m^{-3}

[3 marks]

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Volume =..... m^3

Reference: AQA AS Physics Examination Paper 1 June 2018

MARK SCHEME

Question	Answers	Additional Comments/Guidelines	Mark
1.1	(use of $\rho = M/V$) $M = 4.0 \times 10^{-6} \times 920 = 3.68 \times 10^{-3}$ (kg)✓ weight = $3.68 \times 10^{-3} \times 9.81 = 3.6 \times 10^{-2}$ (N)✓	ecf for second mark 1 sig.fig. -1 mark	1 1
1.2	$V = 3.68 \times 10^{-3}/1000 = 3.7\ (3.68) \times 10^{-6}\ m^3$✓	ecf 5.1 from mass calculation	1
1.3	THREE FROM: any mass divided by 7800✓ $V \times 7800 + (4.0 \times 10^{-6} - V) \times 920 = 3.9 \times 10^{-3}$ ✓ $6880\ V = 3.9 \times 10^{-3} - 3.68 \times 10^{-3}$ ✓ $V = 3.2 \times 10^{-6}\ m^3$✓	Ignore mass value if awarding first mark	1 1 1 (MAX 3)
Total			6

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

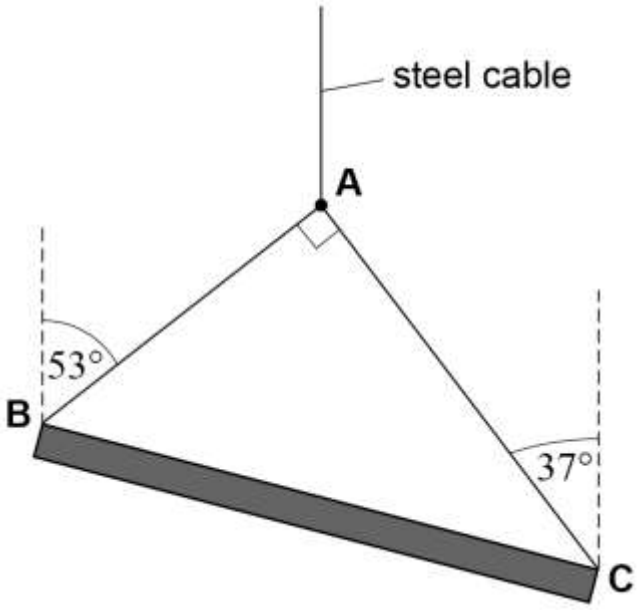
Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION TWO

2. Figure 4 shows a uniform beam supported by two light cables, **AB** and **AC**, which are attached to a single steel cable from a crane. The beam is stationary and in equilibrium.

Figure 4



2.1 State **two** necessary conditions for the beam to be in equilibrium.

[2 marks]

Condition 1

.....

.....

Condition 2

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2.2 State what is meant by the centre of mass.

[1 mark]

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2.3 Explain why the centre of mass of the beam in **Figure 4** must be vertically below **A**.

[2 marks]

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2.4 The weight of the beam is 12 000 N

Calculate the tension T_1 in cable **AB** and the tension T_2 in cable **AC**.

[4 marks]

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T_1 = ... N

T_2 =..... N

2.5 The steel cable from the crane has a circular cross-section of diameter 1.5×10^{-2} m

The cable is 12 m long.

Calculate the extension of the cable caused by the weight of the beam. You can assume that the weights of all cables are negligible.

Young modulus of steel = 2.0×10^{11} Pa

[3 marks]

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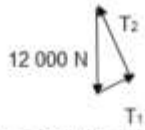
Extension =..... m

Reference: AQA AS Physics Examination Paper 1 June 2018

MARK SCHEME

Question	Answers	Additional Comments/Guidelines	Mark
2.1	resultant/overall/sum of force = 0 OR forces up equal forces down AND forces left equal forces right✓ (sum of) anticlockwise moments (about any point) = (sum of) clockwise moments/zero resultant moment/torque✓		1 1
2.2	EITHER the point through which (the line of action of) a force has no turning effect/causes no rotation/ no torque✓ OR where the mass of the body can be considered to be concentrated OR where the weight can be considered to act✓	NOT where mass can be considered to act Ignore reference to force of gravity	1
2.3	so there is not a resultant moment/turningeffect / turning forceOR moments do not balance OR (beam) does not rotate/oscilate/swing ✓ about A/ because A is pivot ✓	Allow moments balanced for no resultant moment	1 1
2.4	 $T_1 = 12\,000 \cos 53$✓ $T_1 = 7200$ (7221) (N)✓ $T_2 = 12\,000 \sin 53$✓ $T_2 = 9600$ (9583) (N)✓ OR	If T_1 and T2 are the wrong way round get 3 out of 4 If scale drawing 2 max +/- 300(N) If values out by a factor of 10 then -1 (i.e. confusion over g)	1 1 1 1
2.5	$T_1 \cos 53 + T_2 \cos 37 = 12\,000$✓ $T_1 \sin 53 = T_2 \sin 37$✓ $T_2 = T_1 \sin 53 / \sin 37$ hence $T_1 \cos 53 + T1 \sin 53 \cos 37 / \sin 37 = 12\,000$ $T_1 = 7200$ (7221) (N)✓ $T_2 = 7221 \sin 53 / \sin 37 = 9600$ (9583) (N)✓		
2.6	(use of $\Delta l = Fl/AE$) $A = \pi \times (0.75 \times 10^{-2})^2$✓ ($= 1.767 \times 10^{-4}$) $\Delta l = 12\,000 \times 12 / (1.767 \times 10^{-4} \times 200 \times 10^{9})$✓ $\Delta l = 4.1 \times 10^{-3}$ (m)✓	No attempt to calculate area scores zero wrong area (e.g. d^2 or $2\pi r$ or $2\pi rl$) maximum 1 mark unless diameter used for radius in πr^2 then maximum 2 mark accept 4.0×10^{-3} If 4×10^{-3} then -1 as 1 sig. fig.	1 1 1
Total			**12**

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

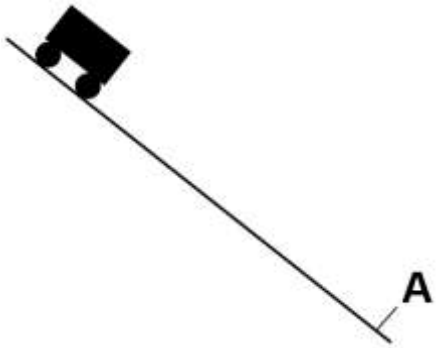
Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION THREE

3. Figure 1 shows a truck moving freely down a ramp inclined at an angle to the horizontal.

Figure 1



The truck starts from rest at the top of the ramp and reaches point **A**. Friction and air resistance are negligible.

As the truck moves down the ramp to point **A**, its centre of mass has a total vertical displacement of 8.0 m

3.1 Calculate the speed of the truck at point **A**.

[2 marks]

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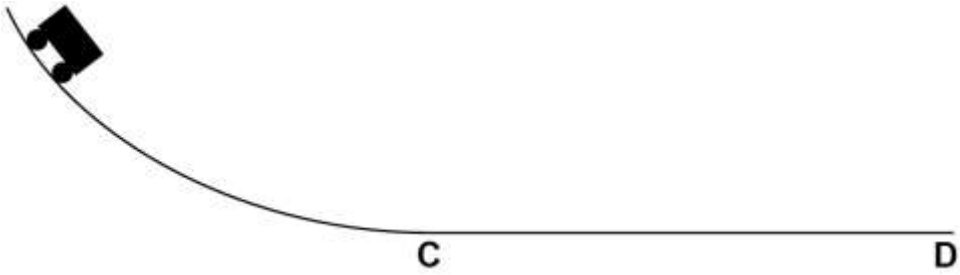
Speed =..... m s^{-1}

3.2 Figure 2 shows the truck moving down a ramp with a varying slope.

Figure 2



The truck starts from rest and moves freely down the ramp. It reaches point **C** and then moves along the horizontal runway to **D**. Friction and air resistance are negligible.

Discuss how the acceleration of the truck in **Figure 2** differs from the acceleration of the truck in **Figure 1.**

[3 marks]

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3.3 The total vertical displacement of the centre of mass of the truck in **Figure 2** is also 8.0 m

The speed of the truck when it reaches the horizontal runway is the same as the speed of the truck in **Figure 1** when it reaches point **A**.

Explain why.

[1 mark]

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3.4 The horizontal runway in **Figure 2** has negligible friction and air resistance. As the truck moves along the runway, it starts to rain. The rain falls vertically and water collects in the truck.

Discuss whether there are any changes in the momentum of the truck and collected water.

[3 marks]

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Reference: AQA AS Physics Examination Paper 1 June 2018

MARK SCHEME

Question	Answers	Additional Comments/Guidelines	Mark
3.1	*(use of gain in E_k = loss in E_p)* $1/2mv^2 = mgh$ $1/2v^2 = 9.81 \times 8.0$✓ $(v = \sqrt{(2 \times 9.81 \times 8.0)}) = 13\ (12.5)\ (m\ s^{-1})$ ✓	Bald correct answer scores 1 mark If use $v^2 = u^2 + 2as$ then zero Unless resolved g along slope If use 10 for g (-1) Gets second mark if answer rounds to 13	 1 1
3.2	THREE FROM: acceleration of truck in Fig.1 is constant✓ In Fig.2 acceleration is greater/greatest at start/top✓ acceleration decreases✓ reference to zero acceleration/uniform velocity between C and D✓ because the component of weight/acceleration parallel to the slope changes✓		 1 1 1 (3 MAX)
3.3	the loss of (gravitational) potential energy is the same hence gain in kinetic energy is the same✓		1
3.4	THREE FROM: rain has no (initial) horizontal momentum ✓ vertical momentum of rainwater decreases ✓ there is no external (horizontal) impulse/force on the truck (and water system) ✓ mass (of truck) increases but speed/velocity decreases✓ horizontal momentum of water increases (but horizontal momentum of	If say: 'vertical momentum/velocity of rain drops/water changes to horizontal (momentum/velocity)' score 2 marks	 1 1 1 (3 MAX)
	truck decreases by same amount) ✓		
	(so) no change in (horizontal) momentum of truck and collected water/total momentum ✓	Cannot score last mark if stated that speed/velocity of truck does not change	
Total			9

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

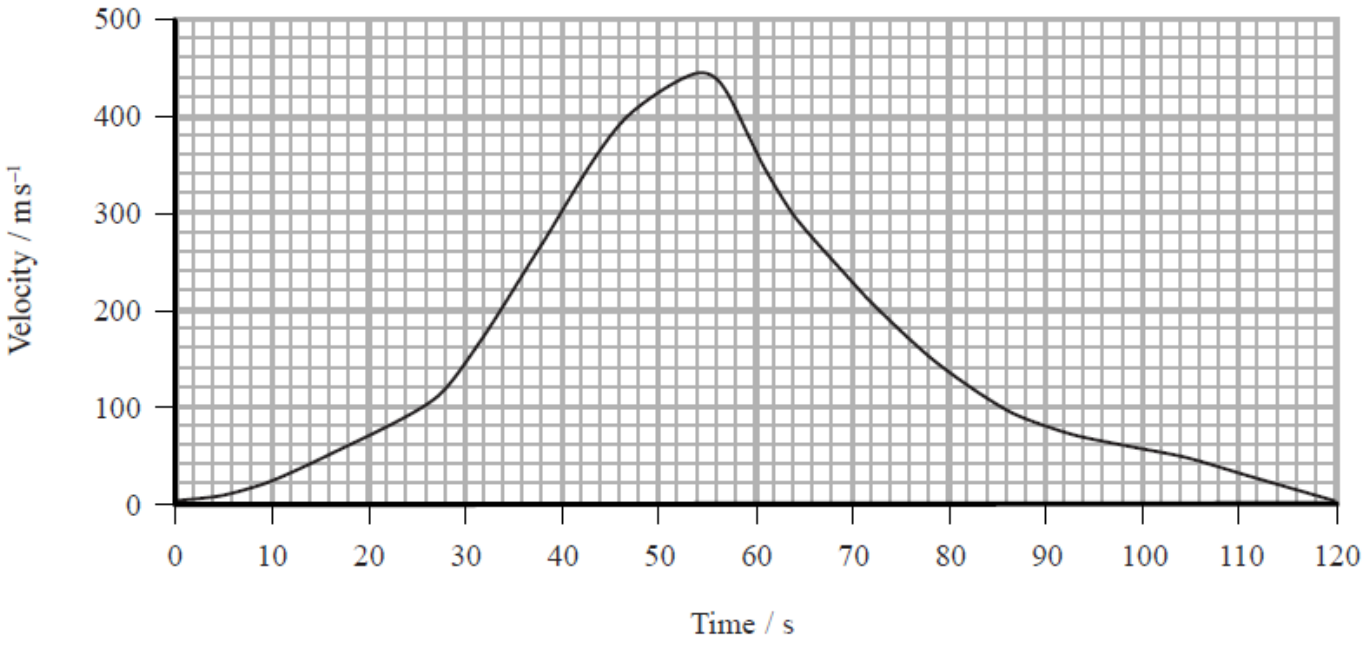
Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION FOUR

4. The world land speed record of 341 m s^{-1} was set in October 1997. In an attempt to break this record, a new supersonic car has been developed called the Bloodhound.

The developers of the Bloodhound have used computer modelling to produce a velocity-time graph for the predicted motion of the car, on a straight track, during the record attempt.



4.1 A track of length 23 km is available for the record attempt.

Determine whether this track is long enough.

[3 Marks]

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The car has two different engines: a jet engine providing a thrust of 89 kN and a rocket engine providing a thrust of 120 kN.

4.2 The jet engine runs throughout the car's acceleration stage. The rocket engine runs for only part of that stage.

State the time at which the rocket engine is started during the car's predicted motion.

[1 Mark]

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4.3 Use the graph to determine the maximum positive acceleration of the car.

[2 Marks]

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Maximum positive acceleration of the car = ... ms^{-2}

4.4 Calculate a value for the frictional force acting on the car when the positive acceleration is a maximum.

[3 Marks]

Mass of car including fuel at this time = 7790 kg

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Frictional force during maximum positive acceleration = ... N

4.5 Discuss, with reference to the graph, the factors that would have been used to predict the motion of the car over the 120 s.

[6 Marks]

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Reference: EdExcel AS Physics Paper 1 June 2018 Examination

MARK SCHEME

Question Number	Acceptable answers		Additional guidance	Mark
4.1	• Attempt to find area under the graph • Length from 18 000 m to 20 000 m • Comparison of calculated value to 23 km e.g. The length is long enough	(1) (1) (1)	MP1: use of triangles or counting squares MP3: conclusion to be consistent with calculated value Example of calculation Area under the graph (counting large squares) $= 18.7 \times 100\ m\ s^{-1} \times 10\ s = 18\ 700\ m$	3
4.2	• 26 - 28 s	(1)	Unit required	1
4.3	• Use of gradient of the graph between 28 and 46 s • Acceleration = 16 - 17 m s^{-2}	(1) (1)	Example of calculation Gradient of tangent $= \frac{490\ m\ s^{-1} - 0\ m\ s^{-1}}{52\ s - 22\ s}$ Acceleration = 16.3 m s^{-2}	2
4.4	• Use of $\Sigma F = ma$ using a from (ii) • $\Sigma F = (89 + 120) \times 10^3$ N − frictional force • Frictional force = 80 kN to 84 kN (full ecf for acceleration)	(1) (1) (1)	Example of calculation $(89 + 120) \times 10^3$ N - $F = 7790$ kg $\times$ 16.3 m s^{-2} $F = 82.0 \times 10^3$ N	3

4.5

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.

Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points
6	4
5 - 4	3
3 - 2	2
1	1
0	0

Indicative content

- At greater speed, the drag force is greater
- Resultant force decreases **Or** acceleration decreases
- When the rocket is started the (resultant) force/thrust increases
- The mass/weight of the car decreases as fuel is used up
- Increasing the acceleration (for a given applied force)
- When the brakes are applied, there is a deceleration
  Or when the brakes are applied the resultant force is in the opposite direction
  Or deceleration (due to drag forces) decreases due to smaller drag forces acting on the car at lower speeds

The following table shows how the marks should be awarded for structure and lines of reasoning

	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

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

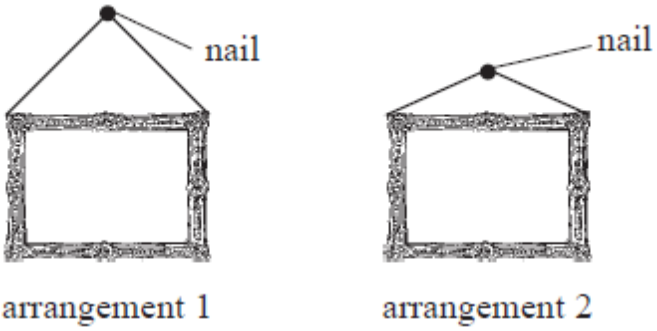
A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION FIVE

A thin wire of negligible mass is used to hang a picture on a wall. The wire is hung over a nail and can be attached to the picture using arrangement 1 or arrangement 2, as shown.



arrangement 1 arrangement 2

5.1 Deduce which wire arrangement should be used to keep the tension in the wire as small as possible.

[4 Marks]

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5.2 It was observed that if the wire was not hung with its midpoint over the nail, as in **Diagram 1**, the picture moved and then remained in the position shown in **Diagram 2**.

Diagram 1

Diagram 2

Use the idea of moments to explain why.

[3 Marks]

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Reference: EdExcel A Level Physics Paper 1 June 2018 Examination

MARK SCHEME

Question Number	Acceptable answers	Additional guidance	Mark
5.1	• Weight of the picture is equal to the vertical component of tension (1) • $mg/2 = T\cos\theta$ where θ is the angle between the wire and the vertical (1) • As the angle (to the vertical) is the smaller in arrangement 1, the cosine of the angle will be larger (1) • Arrangement 1 as the tension in the wire is lower than in arrangement 2 (1)	MP1: may be implied in an equation, accept $mg = T\cos\theta$ MP1/2: $mg/2 = T\cos\theta$ with θ defined scores 2 marks MP2/3: the angle used must be defined in words or on the diagram. Answer can be in terms of sin θ if θ defined as the angle between the wire and the horizontal e.g.MP2: $mg = 2T\sin\theta$ MP3: angle larger in 1 so sine of angle is larger MP4 conditional MP2 or MP3	4
5.2	• The weight does not act through the nail/pivot Or the centre of gravity is not in line/below the nail/pivot Or there is a perpendicular distance between the weight and the nail/pivot (1) • There is now a moment of the weight Or the anticlockwise moment is greater than the clockwise moment (1) • The idea that the picture stops moving when the c of g is below the nail (1)	Accept centre of mass for centre of gravity (Allow annotations to a diagram with additional explanation for MP1/3) MP3 Accept: the turning moment being 0 Or the clockwise moments equal to the anti-clockwise moments	3

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION SIX

(a) On the axes of Fig. 7.1, sketch a stress against strain graph for a typical ductile material.

Fig. 7.1

[2]

(b) Circle from the list below a material that is ductile.

jelly copper ceramic glass **[1]**

(c) Define *ultimate tensile strength* of a material.

.....

..... **[1]**

(d) State *Hooke's law*.

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..... **[1]**

(e) Fig. 7.2 shows a mechanism for firing a table tennis ball vertically into the air.

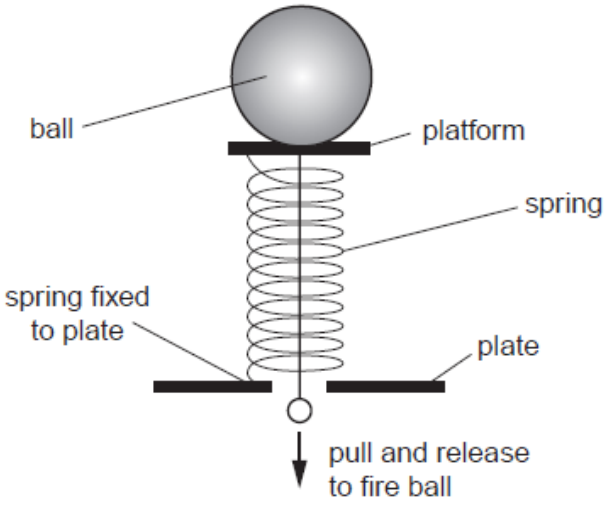


Fig. 7.2

The spring has a force constant of $75\,N\,m^{-1}$. The ball is placed on the platform at the top of the spring.

(i) The spring is compressed by 0.085 m by pulling the platform. Calculate the force exerted by the compressed spring on the ball **immediately** after the spring is released. Assume both the spring and the platform have negligible mass.

force = ...N **[2]**

(ii) The mass of the ball is 2.5×10^{-3} kg. Calculate the initial acceleration of the ball.

acceleration = ... $m\,s^{-2}$ **[1]**

(iii) Calculate the maximum height that could be gained by the ball. Assume all the elastic potential energy of the spring is converted into gravitational potential energy of the ball.

height = ... m **[3]**

[Total: 11]

Reference: OCR Physics Unit 1 June 2009 Examination

MARK SCHEME

Question			Expected Answers	Marks	Additional Guidance
7	(a)		Straight line through origin (judge by eye) Correct shape of curve in the plastic region	B1 B1	
	(b)		Copper	B1	
	(c)		Maximum stress material can withstand (before fracture)	B1	**Allow**: UTS = breaking stress **Allow**: UTS = breaking force /(cross-sectional) area
	(d)		extension (or compression) $\propto$ force (as long as elastic limit is not exceeded)	B1	**Allow**: 'load' instead of force **Not**: $x \propto F$, unless the labels are defined
	(e)	(i)	force = 75×0.085 $F = 6.38$ (N) ≈ 6.4 (N)	C1 A1	
		(ii)	acceleration = $\frac{6.38}{2.5\times10^{-3}}$ acceleration = 2550 (m s^{-2})	B1	**Note**: $a = \frac{kx - mg}{m}$ gives 2540 (m s^{-2}) Possible ecf
		(iii)	Correct selection of equation: mgh / $\frac{1}{2}kx^2$ / $\frac{1}{2}Fx$ $0.0025\times9.81\times h = \frac{1}{2}\times75\times0.085^2$ height = 11 (m)	C1 C1 A1	 **Note**: Bald answer of 11 (m) scores 3/3 marks
			Total	**11**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

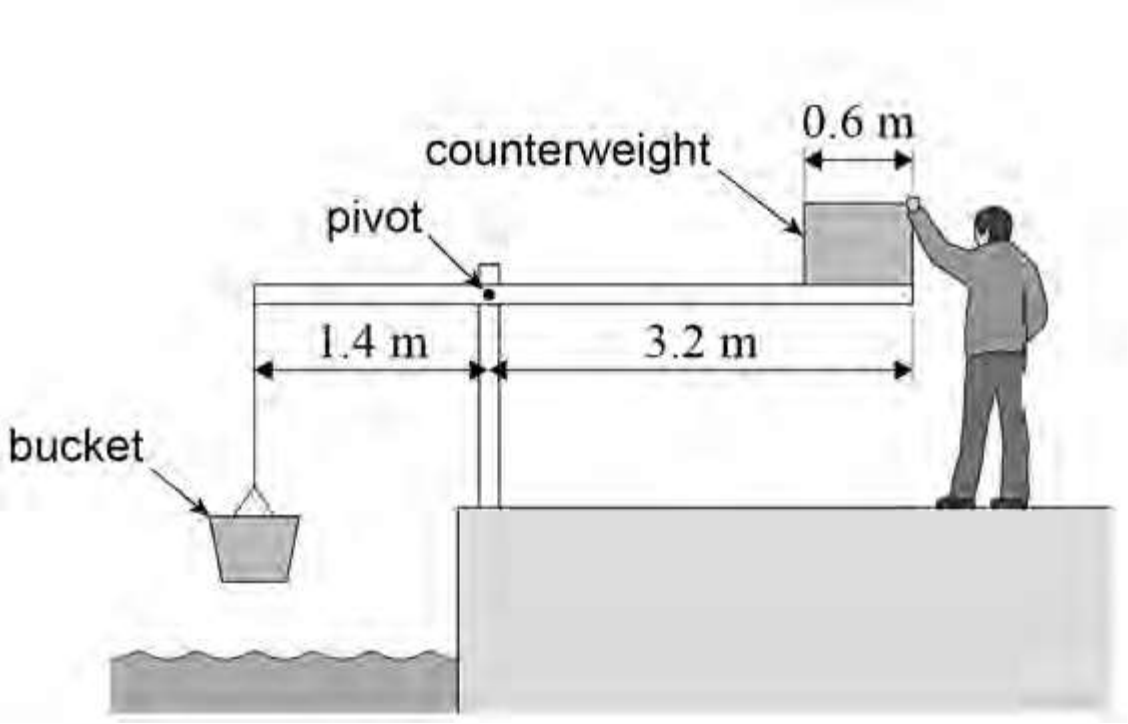
From this question, are there any targets you need to set for revision? What are they?

QUESTION SEVEN

7. A shaduf is a device used to lift water from a well. It consists of an upright support to which a uniform beam is pivoted. It can be assumed that the weight of the beam is negligible. On one end of the beam is a counterweight, and on the other a bucket which can hold the water.

Figure 9 shows a diagram of a typical shaduf.

Figure 9



The counterweight is of uniform material and has a weight of 50 N. It is 0.60 m long.

7.1 Calculate the moment of the counterweight about the pivot when the beam is horizontal.

[2 marks]

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Moment = ... Nm

The bucket has a weight of 120 N and has a capacity of 0.16 m^3. When the bucket is half full, a force is required at the end of the beam to lift the bucket and water.

7.2 Calculate the value of this force when the beam is horizontal.

density of water = 1000 kg m^{-3}

[5 marks]

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Additional Force = ... N

7.3 Explain how the force in Question **7.2** would be different if the weight of the beam is not considered to be negligible.

[3 marks]

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Reference: AQA A Level Physics Paper 1 Examination Specimen Paper

MARK SCHEME

Question	Answers	Additional Comments/Guidance	Mark
7.1	Distance to centre of mass of counterweight from pivot =2.9 m ✓ Moment = $(f \times d = 50 \times 2.9 =)145$ (N m) ✓	No credit for use of 3.2 m (or 2.6 m) here, but maybe ecf later	2
7.2	mass of water = 0.08 × 1000 (= 80 kg)✓ total weight of bucket + water = 80*g* + 120 (= 905 N)✓ moment of bucket + water = 905 × 1.4 = 1270 (N m)✓ 905 × 1.4 = 145 + *F*×3.2 ✓ 350 (N)✓	No credit for 1000 x 1.6 here Allow ecf from any mass Ecf from Q6.1	5
7.3	Weight of beam acts to right of the pivot/centre of mass is to the right of the pivot ✓ provides an additional **clockwise moment** ✓ Therefore the value calculated in Q6.2 would be less to have equilibrium ✓	Need "moment" and some sense of direction No credit for unsubstantiated statement of change of force.	3

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

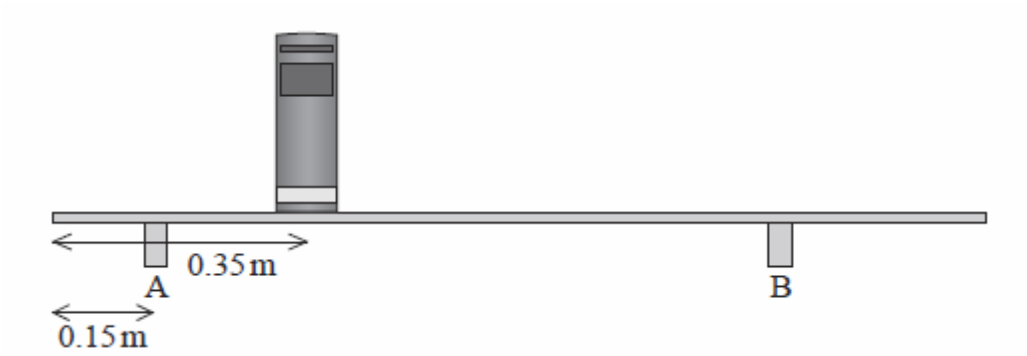
A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION EIGHT

8. Two brackets, **A** and **B**, support a shelf of length 1.2 m. Bracket A is positioned 0.15 m from the left-hand end of the shelf. A book is placed 0.35 m from the left-hand end of the shelf as shown.



8.1 The normal contact forces of each bracket on the shelf are equal.

Determine the distance of bracket B from the left-hand end of the shelf.

Weight of book = 8.5 N

Weight of shelf = 14 N

[5 Marks]

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8.2 Bracket **B** is moved closer to the left-hand end of the shelf.

Explain the effect on the magnitude of the normal contact force of bracket **B** on the shelf.

[2 Marks]

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Reference: EdExcel International A Level Physics Paper 1 January 2019 Examination

MARK SCHEME

Question Number	Answer		Mark
8.1	• Use of $\Sigma F = 0$, seen or implied	(1)	
	• $F = 11$ N	(1)	
	• Use of moment of force = Fx (with any corresponding force and known distance from an end, A or midpoint)	(1)	
	• Use of the principle of moments	(1)	
	• $x = 0.86$ m	(1)	**5**
	Example of calculation $F_A + F_B = 8.5$ N + 14 N = 22.5 N $F_A = F_B$ $2F = 22.5$ N $F = 11.25$ N if moments taken from the left end (11.25 N × 0.15 m) + (11.25 N × x) = (8.5 N × 0.35 m) + (14 N × 0.60 m) $x = 0.861$ m if moments taken from midpoint (11.25 N × 0.45 m) = (11.25 N × x) + (8.5 N × 0.25 m) $x = 0.261$ m so distance = 0.261 m + 0.6 m = 0.861 m if moments taken from A (8.5 N × 0.20 m) + (14 N × 0.45 m) = (11.25 N × x) $x = 0.711$ m so distance = 0.711 + 0.15 m = 0.861 m		
8.2	The moment (of B) must be the same	(1)	
	For a smaller distance (from the left end of the shelf), the (normal contact) force must increase	(1)	**2**
	Total for question 13		**7**

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

A

QUESTION NINE

A lift has a mass of 500 kg. It is designed to carry a maximum of 8 people of total mass 560 kg. The lift is supported by a steel cable of cross-sectional area $3.8 \times 10^{-4}\,m^2$. When the lift is at ground floor level the cable is at its maximum length of 140 m, as shown in Fig. 3.1. The mass per unit length of the cable is $3.0\,kg\,m^{-1}$.

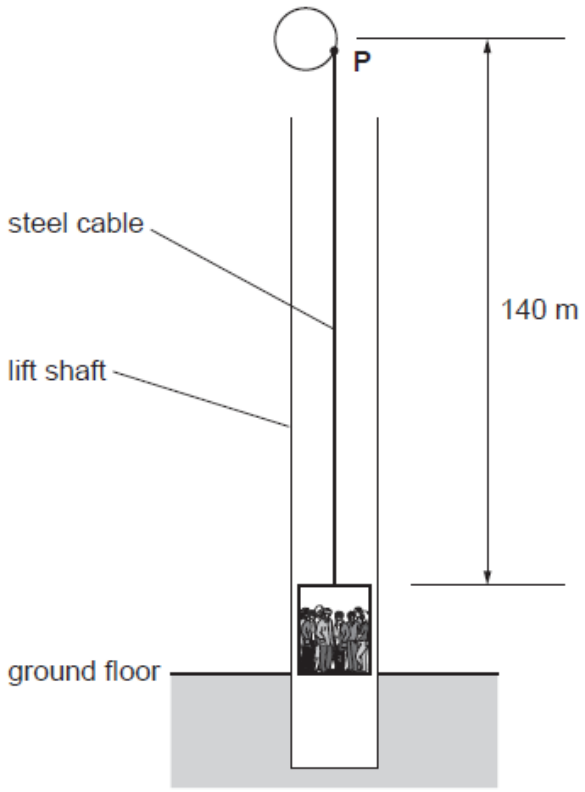

Fig. 3.1

(a) Show that the mass of the 140 m long steel cable is 420 kg.

[1]

(b) (i) The lift with its 8 passengers is stationary at the ground floor level. The initial upward acceleration of the lift and the cable is $1.8\,m\,s^{-2}$. Show that the **maximum** tension in the cable at point **P** is $1.7 \times 10^4\,N$.

[4]

(ii) Calculate the maximum stress in the cable.

stress = ... Pa **[2]**

[Total: 7]

Reference: OCR Physics Unit 1 January 2010 Examination

MARK SCHEME

Question			Expected Answers	Marks	Additional Guidance
3	(a)		mass = $\underline{140 \times 3.0}$ (= 420 kg)	B1	**Allow**: $\frac{420}{3.0} = 140$ (reverse argument)
	(b)	(i)	total mass = 500 + 560 + 420 (= 1480 kg) total weight = 1480 × 9.8(1) / total weight = 14520 (N) net force = 1480 × 1.8 / net force = 2664 (N) tension = 14520 + 2664 tension = 1.7(2) × 10^4 (N)	C1 C1 C1 C1 A0	**Note**: Omitting one of the masses – can score maximum of 3 Omitting two masses – can score maximum of 2 **Examples:** 3 marks if mass of cable is omitted tension = 1908 +10400 = 1.23 × 10^4 (N) 2 marks if mass of cable and people are omitted tension = 900 + 4905 = 5.8 × 10^3 (N) **Note**: 4 marks for 'tension = $(m(g+a) =)$ 1480 × (9.81 + 1.8)'
		(ii)	stress = $\frac{1.72 \times 10^4}{3.8 \times 10^{-4}}$ / stress = $\frac{(b)(i)}{3.8 \times 10^{-4}}$ stress = 4.5(3) × 10^7 (Pa)	C1 A1	Possible ecf from **(i)** **Note**: A tension of 1.7 × 10^4 (N) gives an answer of 4.4(7) × 10^7 (Pa)
			Total	**7**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION TEN

(a) An electron in a particle accelerator experiences a constant force. According to one student, the acceleration of the electron should remain constant because the ratio of force to mass does not change. In reality, experiments show that the acceleration of the electron decreases as its velocity increases. Describe what can be deduced from such experiments about the nature of accelerated electrons.

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.....

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..... **[2]**

(b) Fig. 4.1 shows the velocity vector for a particle moving at an angle of 31° to the horizontal.

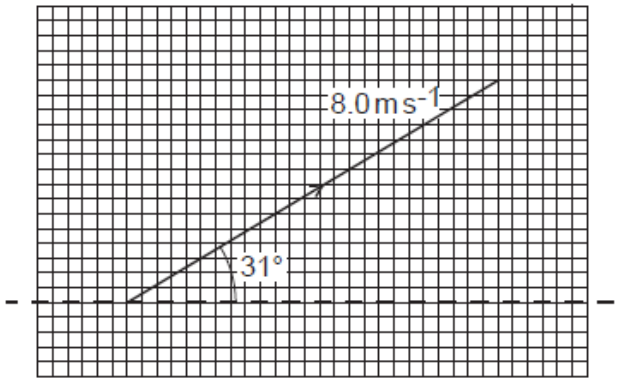


Fig. 4.1

(i) On Fig. 4.1, show the horizontal (*x*-direction) and vertical (*y*-direction) components of the velocity. **[2]**

(ii) Calculate the horizontal (*x*-direction) component of the velocity.

velocity = ... $m\,s^{-1}$ **[1]**

(c) Fig. 4.2 shows a ship **S** being pulled by two tug-boats.

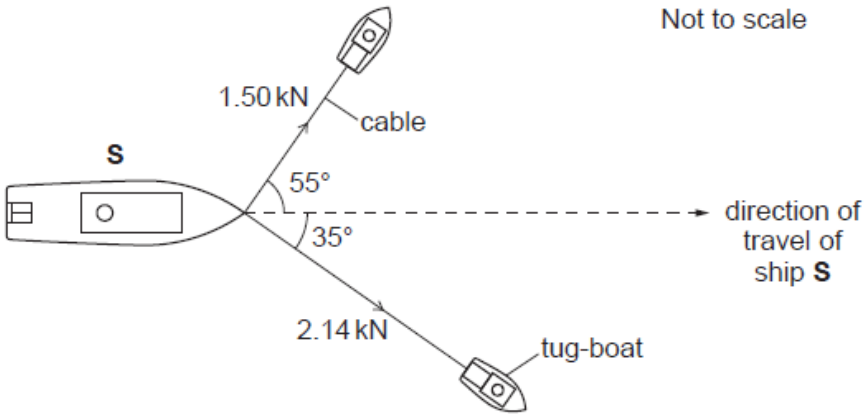


Fig. 4.2

The ship is travelling at a constant velocity. The tensions in the cables and the angles made by these cables to the direction in which the ship travels are shown in Fig. 4.2.

(i) Draw a vector triangle and determine the resultant force provided by the two cables.

resultant force = ... kN **[3]**

(ii) State the value of the drag force acting on the ship **S**. Explain your answer.

.....

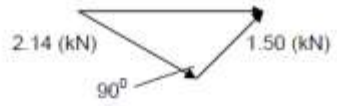
.....

..... **[2]**

[Total: 10]

Reference: OCR Physics Unit 1 January 2010 Examination

MARK SCHEME

Question			Expected Answers	Marks	Additional Guidance
4	(a)		The mass (of the electron) increases as its speed approaches c / speed of light / 3×10^8 m s^{-1}	M1 A1	**Not**: mass 'changes' / 'electron becomes heavier'
	(b)	(i)	A line with correct arrow in the *y* direction has length of 14 to 16 'small squares'	B1	
			A line with correct arrow in the *x* direction has length of 24 to 26 'small squares'	B1	**Note**: If correct arrows are not shown, then maximum mark is 1
		(ii)	component = $(8.0 \cos 31 =) 6.86$ (m s^{-1}) or 6.9 (m s^{-1})	B1	**Allow**: 6.85 as BOD
	(c)	(i)	Correct vector triangle drawn  	B1	**Note**: Expect at least one 'label' on the sketch, eg: 2.14, 1.5, 90^0 The 'orientation' of the triangle is not important The directions of all three arrows are required
			(resultant force)^2 = $2.14^2 + 1.50^2$	C1	
			resultant force = 2.61 (kN)	A1	**Allow**: 2 sf answer of 2.6 (kN) **Allow** a scale drawing; 2 marks if answer is within ±0.1 kN and 1 mark if ± 0.2 kN **Alternative** for the C1 A1 marks: 1.50cos(55) or 2.14cos(35) C1 resultant force = 1.50cos(55) + 2.14cos(35) resultant force = 2.61 (kN) A1
		(ii)	2.6(1) (kN)	B1	Possible ecf
			(Constant velocity implies) zero net force / zero acceleration	B1	**Not**: '*resultant force = drag*' since the first B1 assumes this
			Total	**10**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

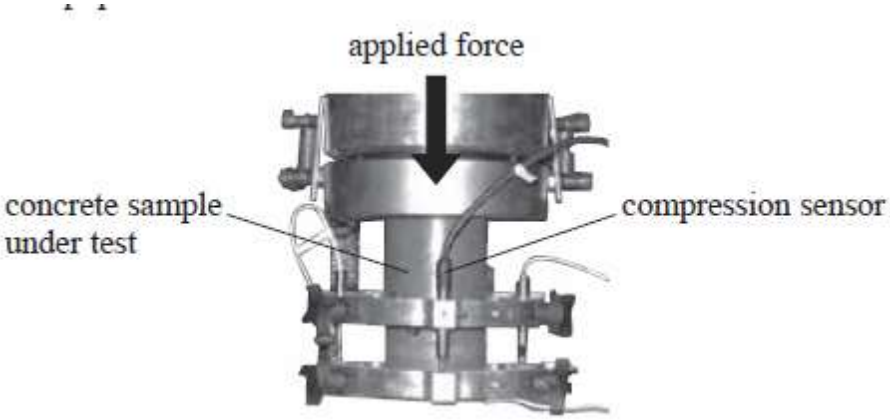
Revision Target

From this question, are there any targets you need to set for revision? What are they?

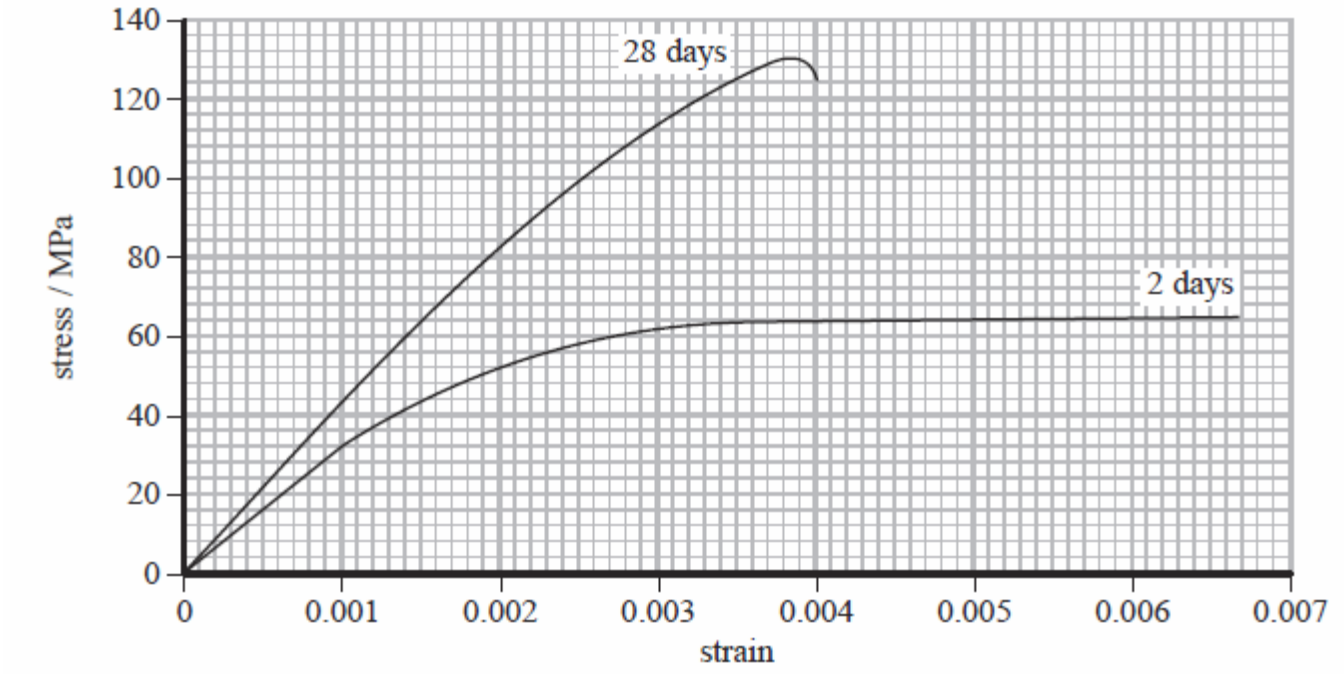
QUESTION ELEVEN

11. When concrete is first made it has a high moisture content. As the concrete dries its properties change.

A manufacturer of concrete carried out compression testing of cylindrical samples of concrete using the equipment shown.



The diagram shows stress-strain graphs, up to the fracture point, for concrete samples 2 days and 28 days after being made.



11.1 As the concrete dries its Young modulus increases.

Show that the value for the Young modulus of the concrete after it has dried is at least 1.3 times greater.

[4 Marks]

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11.2 The energy absorbed before fracture by the 28-day old sample is less than the energy absorbed before fracture by the 2-day old sample.

The area under a stress-strain graph gives the energy absorbed per unit volume of the sample.

The energy absorbed before fracture by the 2-day old sample is 0.35 MJ m^{-3}.

Determine the percentage reduction in the energy absorbed before fracture between the 2-day old and the 28-day old samples.

You may assume that the volumes of the cylindrical samples are the same.

[3 Marks]

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11.3 Manufacturers recommend leaving concrete blocks to dry for at least 28 days before use.

Discuss why.

[3 Marks]

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Reference: EdExcel International A Level Physics Paper 1 January 2019 Examination

MARK SCHEME

Question Number	Answer		Mark
11.1	• Use of Young modulus = gradient (of either initial linear region of graph)	(1)	
	(MP1 accept ratios of co-ordinates up to strains of (E_{28})0.0015 or (E_2) 0.0014)		
	• See 3.2 to 3.3 × 10^{10} (Pa) **Or** 4.2 to 4.4 × 10^{10} (Pa)	(1)	
	• Comparison of the two values obtained i.e. use of E_{28}/E_2 **Or** $(E_{28}-E_2)/E_2$	(1)	
	• E_{28}/E_2 = 1.30 to 1.40 **Or** $(E_{28}-E_2)/E_2$ = 0.30 to 0.40	(1)	**4**
	(MP4 is conditional on candidates using the linear sections for both graphs in MP1)		
	Example of calculation $E_{28} = \frac{140 \times 10^6 \text{ Pa}}{0.0032} = 4.38 \times 10^{10}$ Pa $E_2 = \frac{104 \times 10^6 \text{ Pa}}{0.0032} = 3.25 \times 10^{10}$ Pa		
	$E_{28}/E_2 = \frac{4.38 \times 10^{10} \text{ Pa}}{3.25 \times 10^{10} \text{ Pa}} = 1.35$		
11.2	• Use of counting squares or approximation of the area to a series of shapes from the 28-day graph	(1)	
	• $\frac{0.35 \times 10^6 - \text{area under 28-day graph}}{0.35 \times 10^6}$	(1)	
	• Percentage reduction = 12.0 % to 15.0 %	(1)	**3**
	Example of calculation ΔE_{28} = (½×80 × 10^6 Pa×0.0019) + [½(80 + 128) Pa × 10^6 × (0.0038 – 0.0019)] + (64 ×0.0001 × 4 × 10^6 Pa) = 299 200 J m^{-3}		
	Percentage reduction = $\frac{350\,000 \text{ J m}^{-3} - 299\,200 \text{ J m}^{-3}}{350\,000 \text{ J m}^{-3}} \times 100 = 14.5$ %		

11.3	• The breaking stress/force is greater	(1)	
	• The concrete is less flexible **Or** the concrete is stiffer (Do not accept a greater Young modulus)	(1)	
	• There is a smaller plastic region **Or** the elastic region is greater **Or** there's little change in the toughness **Or** a change in the properties of the concrete after you've used it could cause problems	(1)	**3**
	Total for question 17		**10**

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION TWELVE

The force against length graph for a spring is shown in Fig. 6.1.

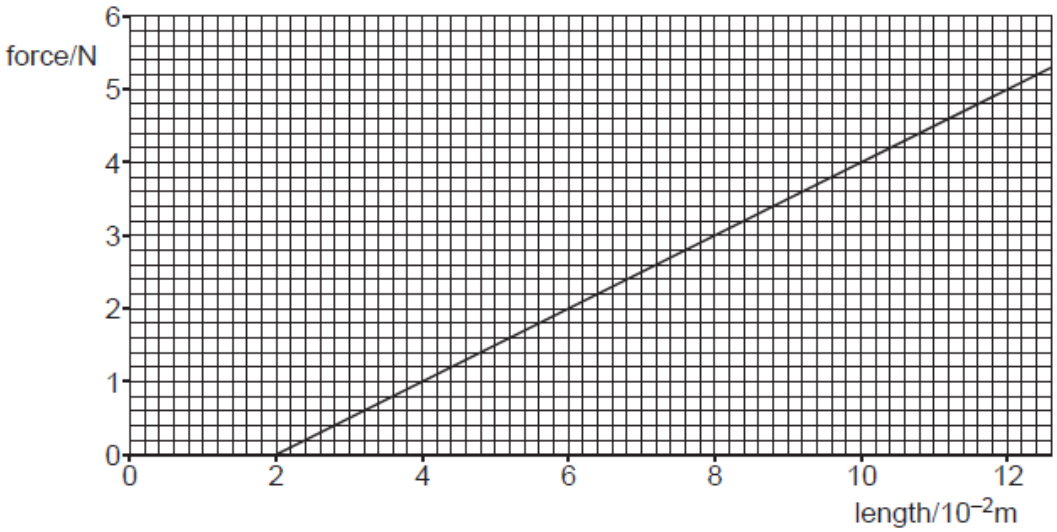

Fig. 6.1

(a) Explain why the graph does not pass through the origin.

.....

..... **[1]**

(b) State what feature of the graph shows that the spring obeys Hooke's law.

.....

..... **[1]**

(c) The gradient of the graph is equal to the force constant *k* of the spring. Determine the force constant of the spring.

force constant = ... $N m^{-1}$ **[2]**

(d) Calculate the work done on the spring when its length is increased from 2.0×10^{-2}m to 8.0×10^{-2}m.

work done = ... J **[2]**

(e) One end of the spring is fixed and a mass is hung vertically from the other end. The mass is pulled down and then released. The mass oscillates up and down. Fig. 6.2 shows the displacement *s* against time *t* graph for the mass.

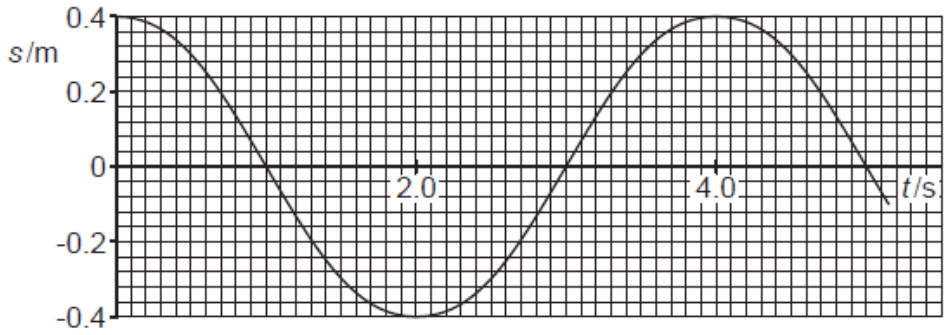

Fig. 6.2

Explain how you can use Fig. 6.2 to determine the **maximum** speed of the mass. You are not expected to do the calculations.

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.....

.....

..... **[2]**

[Total: 8]

Reference: OCR Physics Unit 1 January 2010 Examination

MARK SCHEME

Question			Expected Answers	Marks	Additional Guidance
6	(a)		The graph shows length and not extension of the spring / spring has original length (of 2.0 cm) (AW)	B1	**Allow**: 'length cannot be zero'
	(b)		Straight line (graph) / linear graph / force ∝ extension / constant gradient (graph)	B1	**Not** 'force ∝ length'
	(c)		force constant = $\frac{2.0}{0.04}$ force constant = 50 (N m^{-1})	C1 A1	**Note**: The mark is for any correct substitution **Allow**: 1 mark for 0.5 (N m^{-1}) – 10^n error **Allow** 1 mark for 5/12 × 10^{-2} = 41.7 or 4/10 × 10^{-2} = 40 or 3/8 × 10^{-2} = 37.5 or 2/6 × 10^{-2} = 33.3 or 1/4 × 10^{-2} = 25
	(d)		work done = $\frac{1}{2}Fx$ or $\frac{1}{2}kx^2$ or 'area under graph' work done = $\frac{1}{2} \times 3.0 \times 0.06$ or $\frac{1}{2} \times 50 \times 0.06^2$ work done = 0.09 (J)	C1 A1	 Possible ecf **Note**: 1 sf answer is allowed
	(e)		Find the gradient / slope (of the tangent / graph) Maximum speed at 1.0s / 3.0s / 5.0s / steepest 'part' of graph / displacement = 0	B1 B1	 **Allow**:2 marks for 'steepest / maximum gradient'
			Total	**8**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION THIRTEEN

(a) Fig. 7.1 shows a length of tape under tension.

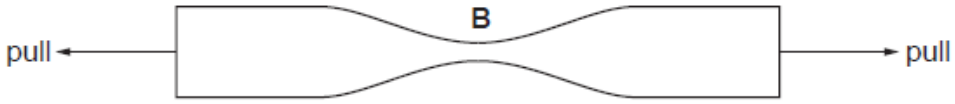

Fig. 7.1

(i) Explain why the tape is most likely to break at point **B**.

.....

..... **[1]**

(ii) Explain what is meant by the statement:

'the tape has gone beyond its elastic limit'.

.....

.....

..... **[1]**

(b) Fig. 7.2 shows one possible method for determining the Young modulus of a metal in the form of a wire.

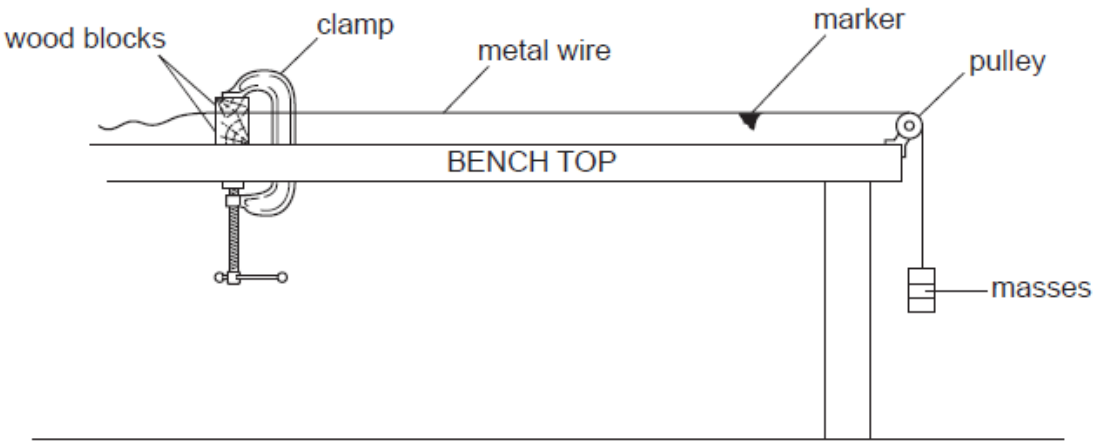

Fig. 7.2

Describe how you can use this apparatus to determine the Young modulus of the metal. The sections below should be helpful when writing your answers.

The **measurements** to be taken:

In your answer, you should use appropriate technical terms, spelled correctly.

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The **equipment** used to take the measurements:

In your answer, you should use appropriate technical terms, spelled correctly.

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How you would **determine** Young modulus from your measurements:

.....

.....

.....

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.....

.....

[8]

[Total: 10]

Reference: OCR Physics Unit 1 January 2010 Examination

MARK SCHEME

Question			Expected Answers	Marks	Additional Guidance
7	(a)	(i)	It has maximum / large / increased stress at this point	B1	**Allow**: it has 'same force but thinner/smaller area' **Not**: Thin / small area
		(ii)	The tape has (permanent) extension / deformation when the force / stress is removed (AW)	B1	**Note**: Need reference to force or stress removed **Allow**: '.. does not return to original size / shape / length when force / stress is removed'
	(b)		**Measurement:** ✓ Diameter Any two from: • original / initial length (**Not**: final length) • extension / initial and final lengths • weight / mass **Equipment:** ✓ Micrometer / vernier (calliper) (for the diameter of the wire) Any two from: • Ruler / (metre) rule / tape measure (for measuring the original length / extension) • Travelling microscope (for measuring extension) • Scales / balance (for measuring the mass & *mg* equation is used or for measuring weight) / Newtonmeter (for the weight of hanging masses) / 'known' weights used **Determining Young modulus:** • stress = force/(cross-sectional) area and strain = extension/original length • Young modulus = stress/strain / Young modulus is equal to the gradient from stress-strain graph (in the linear region)	B1 B1 X 2 B1 B1 × 2 B1 B1	**The term *diameter* to be included and spelled correctly to gain the mark** **The term *micrometer* / *vernier* (*calliper*) to be included and spelled correctly to the gain mark. (ALLOW: Micrometer is used to measure area / radius / thickness – as BOD)** **Allow**: 'known masses & *mg* equation' but **not** 'known masses' **Allow:** stress = *F*/*A* and strain = *x*/*L* **Special case for determining Young modulus:** Gradient from force-extension graph is $\frac{EA}{L}$ B1 Young modulus = gradient × *L*/*A* B1
			Total	**10**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION FOURTEEN

(a) Complete the table of Fig. 1.1 by stating the value or name of each of the remaining three prefixes.

prefix	value
micro (μ)	10^{-6}
mega (M)	
	10^{-9}
tera (T)	

Fig. 1.1

[3]

(b) Circle all the scalar quantities in the list below.

density **weight** **velocity** **volume** **acceleration**

[1]

(c) The distance between the Sun and the Earth is 1.5×10^{11} m. Calculate the time in minutes for light to travel from the Sun to the Earth. The speed of light is $3.0 \times 10^{8}\,m\,s^{-1}$.

time = ... min **[2]**

(d) The terminal velocity of a raindrop falling vertically through air is $4.0\,m\,s^{-1}$.

(i) In terms of the forces acting on the raindrop, explain why it is at terminal velocity.

.....

.....

..... **[2]**

(ii) Fig. 1.2 shows a velocity vector diagram for the falling raindrop in a horizontal crosswind of speed $1.5\,m\,s^{-1}$.

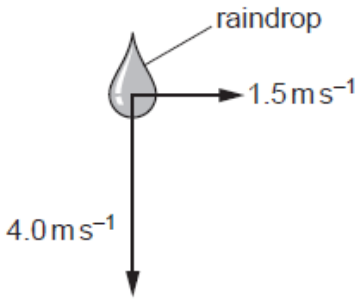

Fig. 1.2

1 On Fig. 1.2, draw an arrow on the raindrop to show the **direction** in which it will travel.

2 Calculate the magnitude of the resultant velocity of the raindrop. Use the space below for your working.

resultant velocity = ... $m\,s^{-1}$ **[3]**

[Total: 11]

Reference: OCR Physics Unit 1 June 2010 Examination

MARK SCHEME

Q 1	Expected Answers	Marks	Additional Guidance
a	10^6 nano (n) 10^{12}	B1 B1 B1	**Allow**: 1000 000 **Allow**: nano / n / nano (N) as BOD **Allow**: 1000 000 000 000
b	Circled quantities: density and volume	B1	
c	$1.5\times10^{11} = 3.0\times10^{8}\times t$ time = $\frac{1.5\times10^{11}}{3.0\times10^{8}}$ / 500 (s) time = 8.33 (min) ≈ 8.3 (min)	C1 A1	**Allow**: Any subject **Note**: Bald 500 (s) scores 1 mark **Allow**: 2 marks for a bald answer of 8.3 **Allow**: Answer as a fraction – 25/3 (min) / 8 min 20 s **Allow**: 1 mark for '(500/3600 =) 0.139'
d(i)	Mention of weight or drag Net / total / resultant force (on drop) is zero 'upward force = downward force' / 'weight = drag' / 'weight balances drag'	B1 B1	**Allow:** (air) resistance / (air) friction for 'drag' **Not:** 'gravity' for 'weight' **but** 'force of gravity' is fine **Not**: 'acceleration = 0' since question requires answer in terms of forces **Not**: 'All forces are equal' **Note**: 'weight = drag' / 'weight balances drag' scores 2 marks
d(ii)1	A downward line / arrow (from the raindrop) leaning to the right	B1	**Note**: Answer **must** be on Fig. 1.2 Judge by eye – the angle is not important
d(ii)2	$v^2 = 1.5^2 + 4.0^2$ velocity = 4.27 (m s^{-1}) ≈ 4.3 (m s^{-1})	C1 A1	**Allow**: 2 marks for a scale drawing with value in the range 4.1 to 4.5. If value in the range 4.0 to 4.1 or 4.5 to 4.6 then give 1 mark **Allow**: 2 marks for a bald answer of 4.3 (m s^{-1})
	Total	**11**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION FIFTEEN

(a) According to Aristotle (384 – 322 B.C.)

'heavier objects fall faster than lighter ones'.

Explain how one experiment carried out by Galileo (1564 – 1642) overturned Aristotle's ideas of motion.

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..... **[3]**

(b) Fig. 2.1 shows an arrangement used in the laboratory to determine the acceleration *g* of free fall.

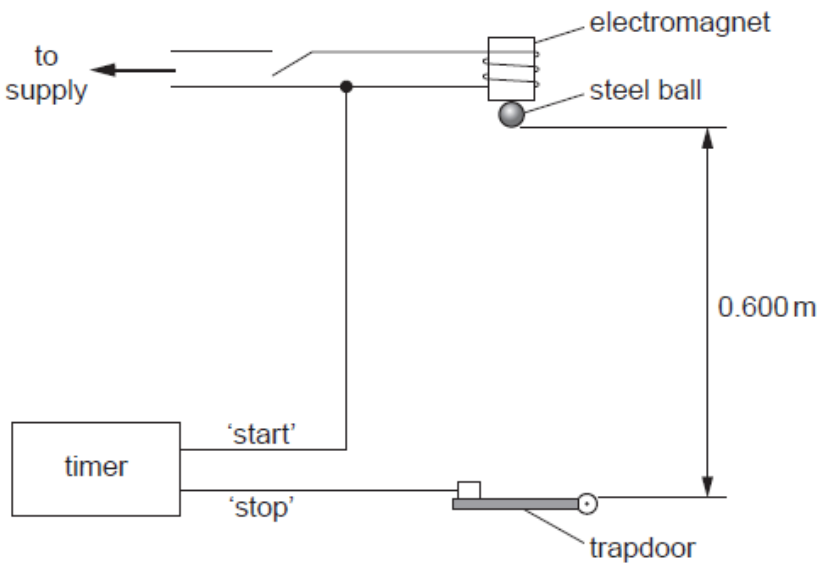

Fig. 2.1

The steel ball is held at rest by an electromagnet. When the electromagnet is switched off, the electronic timer is started and the ball falls. The timer is stopped when the ball opens the trapdoor. The distance between the bottom of the ball and the top of the trapdoor is 0.600 m. The timer records a time of fall of 0.356 s.

(i) Show that the value for the acceleration g of free fall obtained from this experiment is $9.47\,m\,s^{-2}$.

[2]

(ii) State **one** reason why the experimental value in **(i)** is less than $9.81\,m\,s^{-2}$.

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..... **[1]**

(iii) On Fig. 2.2 sketch a graph to show the variation of the vertical distance s fallen by the ball with time t.

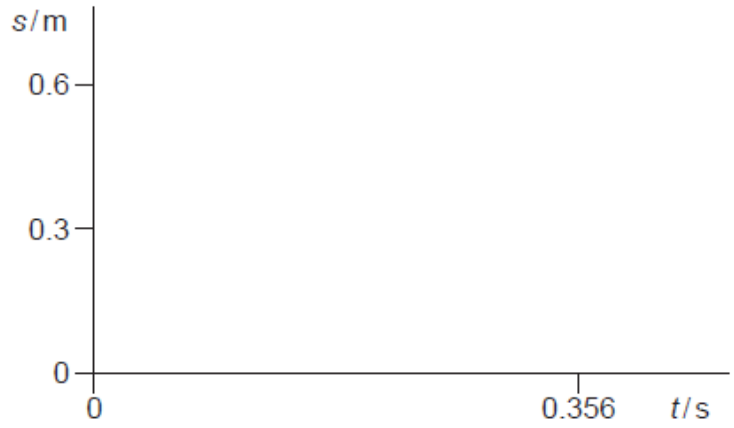

Fig. 2.2

[1]

[Total: 7]

Reference: OCR Physics Unit 1 June 2010 Examination

MARK SCHEME

Q 2	Expected Answers	Marks	Additional Guidance
a	'heavy' and 'light' objects / different weights / different masses dropped (from leaning tower of Pisa) / rolled down incline plane	B1	**Must use ticks on Scoris to show where the marks are awarded** **Not**: 'dropping feather' / 'vacuum' / 'experiment on the Moon' for this first B1 mark but can score subsequent B1 marks
	Objects have the same acceleration (of free fall)	B1	**Not**: 'fall at the same rate / accelerates at the same rate / same speed'
	Objects hit ground at same time	B1	
b(i)	$s = ut + \frac{1}{2}at^2$ and $u = 0$ / $0.600 = \frac{1}{2} \times a \times (0.356)^2$	C1	**Note**: There are no marks for just an answer, since this is a **'show'** question
	$a = \frac{2 \times 0.600}{0.356^2}$	C1	**Allow**: 2 marks for correct substitution with 'a' the subject or $0.600 = \frac{1}{2} \times a \times (0.356)^2$ followed by $a = 9.469$ (more than 3 sf)
	$a = 9.47$ (m s^{-2})	A0	**Note:** Using 'v =.600/0.356' followed by $a = \Delta v / \Delta t = 4.73$ scores zero. (Watch out for $4.734 \times 2 = 9.47$)
b(ii)	Air resistance or drag / residual magnetism or 'sticky' electromagnet / trapdoor takes time to open	B1	**Not**: 'Experiment is not done in a vacuum' / 'friction/resistance'
b(iii)	A 'parabola shape' / graph of increasing positive gradient starting from origin and going through 0.356,0.6	B1	Judge the shape of the graph by eye. A horizontal line from 0.6 must cut the graph within the 'vertical zone provided by 0.356 s ' on the time axis
	Total	**7**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION SIXTEEN

(a) Define the *newton*.

.....

..... **[1]**

(b) Fig. 3.1 shows a spaceship on the surface of the Earth.

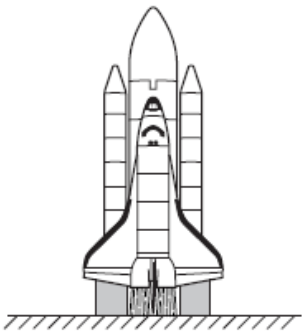

Fig. 3.1

The mass of the spaceship is 1.9×10^6 kg. During lift off, the spaceship rockets produce a vertical upward force of 3.1×10^7 N.

(i) Calculate the weight of the spaceship.

weight = ... N **[1]**

(ii) Calculate the initial vertical acceleration as the spaceship lifts off.

acceleration = ... ms^{-2} **[2]**

(iii) The vertical upward force on the spaceship stays constant. Explain why the acceleration of the spaceship increases after lift off.

.....

.....

.....

..... **[1]**

[Total: 5]

Reference: OCR Physics Unit 1 June 2010 Examination

MARK SCHEME

Q 3	Expected Answers	Marks	Additional Guidance
a	The (net) force (is a newton) when a 1 kg mass has acceleration of 1 m s^{-2}	B1	**Not**: 1 N = 1 kg m s^{-2} because this is too brief for a definition
b(i)	weight = $1.9 \times 10^6 \times 9.81$ weight = 1.86×10^7 (N)	 B1	**Allow**: 9.8 (m s^{-2}) for *g* but not 10 (m s^{-2}) **Allow**: A bald answer of 1.9×10^7 N, but **not** if 10 (m s^{-2}) is seen
b(ii)	net force = 1.24×10^7 (N) or 1.2×10^7 (N) $a = \frac{F}{m} = \frac{1.24 \times 10^7}{1.9 \times 10^6}$ acceleration = 6.53 (m s^{-2}) or 6.5 (m s^{-2})	C1 A1	**Allow**: The C1 mark for "(net force) = $(3.1 - 1.86) \times 10^7$ (N)" **Allow**: 2 marks for a bald answer **Allow**: Answer of 6.3 (m s^{-2}) if 1.9×10^7 (N) is used for weight or net force of 1.2×10^7 (N) is used **Allow**: 1 mark for '$3.1 \times 10^7 / 1.9 \times 10^6 = 16.3$' **Not:** '$1.86 \times 10^7 / 1.9 \times 10^6 = 9.8$'
b(iii)	The mass / weight (of spaceship) decreases (as it loses fuel)	B1	**Allow**: 'g' / acceleration of free fall / gravitational field strength decreases (but **not** gravity decreases) **Not**: 'less drag / air resistance'
	Total	**5**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION SEVENTEEN

(a) Define *work done* by a force.

In your answer, you should use appropriate technical terms, spelled correctly.

.....

..... **[1]**

(b) Fig. 4.1 shows a side view of a roller coaster.

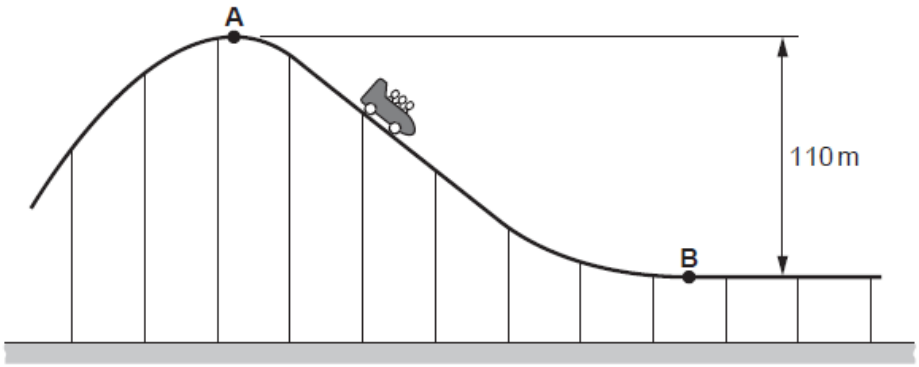

Fig. 4.1

The carriage and its passengers start at rest at **A**. At **B**, the bottom of the ride, the maximum speed of the carriage is $20\,m\,s^{-1}$. The vertical distance between **A** and **B** is 110 m. The length of the track between **A** and **B** is 510 m. The mass of the carriage and the passengers is 4000 kg.

(i) Complete the sentence below.

In your answer, you should use appropriate technical terms, spelled correctly.

As the carriage travels from **A** to **B**, ... energy

is transferred to ..... energy and heat. **[2]**

(ii) By considering this energy transfer from **A** to **B**, determine the average frictional force acting on the carriage and passengers between **A** and **B**.

force = ... N **[3]**

[Total: 6]

Reference: OCR Physics Unit 1 June 2010 Examination

MARK SCHEME

Q 4	Expected Answers	Marks	Additional Guidance
a	✎work done = force × distance <u>moved</u> / <u>travelled</u> (in direction of force) **The term *distance* / *displacement* to be included and spelled correctly to gain mark**	B1	**Note**: Must have reference to 'distance moved / travelled' **Allow**: 'work done = force × displacement' **Must use tick or cross on Scoris to show if the mark is awarded**
b(i)	<u>gravitational</u> potential ✎ kinetic **The term *kinetic* to be included and spelled correctly to gain the second B1 mark**	B1 B1	**Not**: 'potential' on its own **Note**: Ignore any reference to sound **Must use ticks on Scoris to show where the marks are awarded**
b(ii)	(GPE =) $4000 \times 9.81 \times 110$ / (GPE =) 4.32×10^6 **or** (KE =) $\frac{1}{2} \times 4000 \times 20^2$ / (KE =) 8.0×10^5 Work done = $(4000 \times 9.81 \times 110) - (\frac{1}{2} \times 4000 \times 20^2)$ force = $\frac{3.516 \times 10^6}{510}$ force = 6.9×10^3 (N)	C1 C1 A1	 **Allow**: 2 marks if second line is written or $3.5(16) \times 10^6$ (J) is quoted **Allow**: 3 marks for a bald answer of 6.9×10^3 (N)
	Total	**6**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION EIGHTEEN

(a) Fig. 6.1 shows two equal but opposite forces acting on an object.

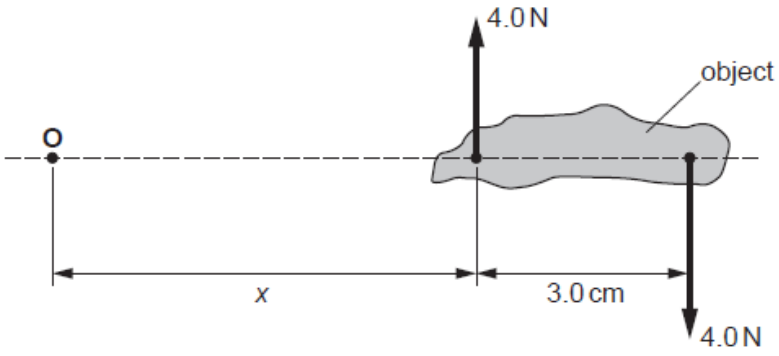

Fig. 6.1

The point **O** is at a distance *x* from the nearer of the two forces.

(i) The separation between the two parallel forces is 3.0 cm. Determine the torque of the couple exerted on the object.

torque = ... N m **[2]**

(ii) Calculate the total moment of the forces about the point **O** and state the significance of this value.

.....

..... **[3]**

(b) State two conditions necessary for an object to be in equilibrium.

.....

.....

..... **[2]**

(c) A concrete paving slab has mass 45 kg and dimensions 0.600 m × 0.600 m × 0.050 m.

(i) Calculate the density of the concrete.

density = ... $kg\,m^{-3}$ **[2]**

(ii) Fig. 6.2 shows the concrete paving slab in equilibrium.

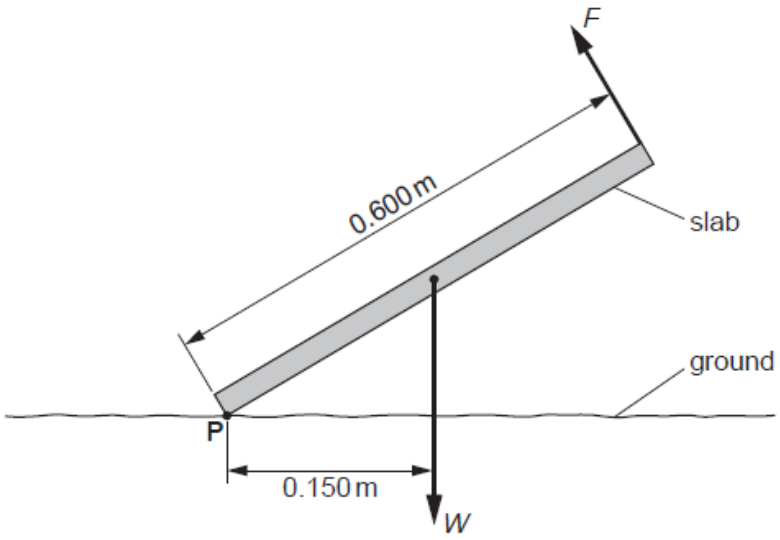

Fig. 6.2

Two forces acting on the slab are shown. The weight of the slab is *W*. The force *F* is applied at right angles to the end of the slab. By taking moments about **P**, determine the size of the force *F*.

F = ... N **[3]**

[Total: 12]

Reference: OCR Physics Unit 1 June 2010 Examination

MARK SCHEME

Q 6	Expected Answers	Marks	Additional Guidance
a(i)	torque = 4.0×0.03 torque = 0.12 (N m)	C1 A1	 **Note**: An answer of 12 scores 1 mark (because cm not converted into m) **Allow**: Full marks for if the centi prefix added; that is 12 N cm **Allow**: 2 marks for a bald 0.12 (N m)
a(ii)	 (total moment =) $(x + 0.03) \times 4.0 - 4.0x$ (total) moment = 0.12 (N m) It is the same as the torque (of the couple) / same as **(a)(i)**	 M1 A1 B1	**Condone** the use of 'N cm' in **a(ii)** **Allow**: Equation with x value of 0.06 (m) or 6 cm **Special case**: 1 mark for (anticlockwise moment =) $4.0x$ or (clockwise moment =) $[x + 0.03] \times 4.0$ seen anywhere on the script **Not**: '0.12 (N m)'
b	Net / total / resultant force = 0 Net / total torque / moment = 0	B1 B1	**Not**: 'forces are balanced' or 'force up = force down' **Allow**: clockwise moment(s) = anticlockwise moment(s)
c(i)	$\rho = \frac{M}{V}$ / density = $\frac{45}{0.600 \times 0.600 \times 0.050}$ density = 2.5×10^3 (kg m^{-3})	C1 A1	 **Allow**: 2 marks for a bald answer of 2.5×10^3 (kg m^{-3})
c(ii)	clockwise moment = anticlockwise moment **or** (weight =) 45×9.81 / (weight =) 441.45 $(45 \times 9.81) \times 0.150 = F \times 0.600$ F = 110 (N)	C1 C1 A1	 **Allow**: 3 marks for a bald 110 (N) **Allow**: 2 marks for 11.25 – mass of 45 kg not changed to N
	Total	**12**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION NINETEEN

(a) Fig. 7.1 shows stress against strain graphs for two materials **X** and **Y** up to their breaking points.

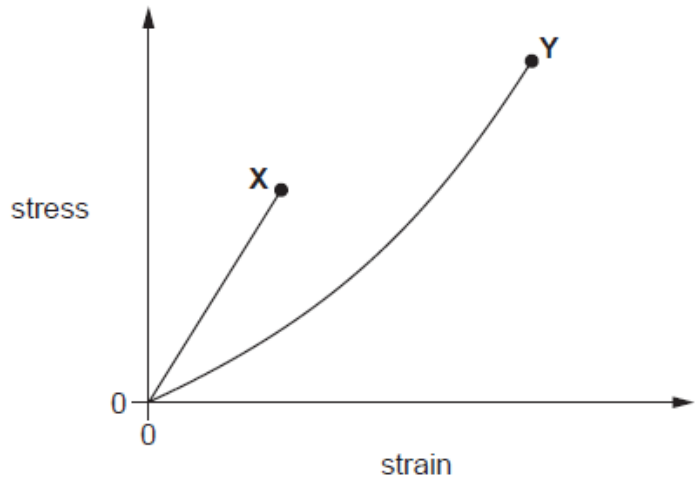

Fig. 7.1

Put a tick (✓) in the appropriate column if the statement applies to the material.

Statement	X	Y
This material is brittle.		
This material has greater breaking stress.		
This material obeys Hooke's Law.		

[1]

(b) Kevlar is one of the strongest man-made materials. It is used in reinforcing boat hulls, aircraft, tyres and bullet-proof vests. Sudden impacts cause this material to undergo plastic deformation.

(i) Explain what is meant by *plastic deformation*.

.....

.....

..... **[1]**

(ii) One particular type of Kevlar has breaking stress 3.00×10^{9} Pa and Young modulus 1.30×10^{11} Pa. For a Kevlar thread of cross-sectional area 1.02×10^{-7} m^2 and length 0.500 m, calculate

1 the maximum breaking force

force = ... N

2 the extension of the thread when the stress is 1.20×10^{9} Pa.

extension = ... m

[4]

[Total: 6]

Reference: OCR Physics Unit 1 June 2010 Examination

MARK SCHEME

Q 7	Expected Answers	Marks	Additional Guidance
a	<table><tr><th>X</th><th>Y</th></tr><tr><td>✓</td><td></td></tr><tr><td></td><td>✓</td></tr><tr><td>✓</td><td></td></tr></table>	B1	All 3 ticks correctly placed for 1 mark
b(i)	Material is permanently deformed / longer when stress / force is removed (wtte)	B1	**Note**: The answer must make reference to stress or forces removed
b(ii)1	(stress = force/area) force = $3.00 \times 10^{9} \times 1.02 \times 10^{-7}$ force = 306 (N) or 310 (N)	C1 A1	**Allow**: Any subject **Allow**: 2 marks for a bald 306 (N) or 310 (N)
b(ii)2	(E = stress/strain) strain = $\frac{1.20 \times 10^{9}}{1.30 \times 10^{11}}$ / strain = 9.23×10^{-3} extension = $9.23 \times 10^{-3} \times 0.500$ extension = $4.6(15) \times 10^{-3}$ (m)	C1 A1	**Allow**: 4.6×10^{-3}, 4.61×10^{-3}, 4.62×10^{-3} **Allow**: 2 marks for a bald $4.6(15) \times 10^{-3}$ (m) **Allow**: 1 mark for using breaking stress of 3.0×10^{9} Pa; this gives an extension of 0.0115 (m) **Alternative answer:** $x = (1.20 \times 10^{9} \times 0.500)/1.30 \times 10^{11}$ C1 (Any subject) extension = $4.6(15) \times 10^{-3}$ (m) A1
	Total	**6**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

DATASHEET

DATA - FUNDAMENTAL CONSTANTS AND VALUES

Quantity	Symbol	Value	Units
speed of light in vacuo	c	3.00×10^{8}	$\mathrm{m\ s^{-1}}$
permeability of free space	μ_0	$4\pi \times 10^{-7}$	$\mathrm{H\ m^{-1}}$
permittivity of free space	ε_0	8.85×10^{-12}	$\mathrm{F\ m^{-1}}$
magnitude of the charge of electron	e	1.60×10^{-19}	C
the Planck constant	h	6.63×10^{-34}	J s
gravitational constant	G	6.67×10^{-11}	$\mathrm{N\ m^2\ kg^{-2}}$
the Avogadro constant	N_A	6.02×10^{23}	$\mathrm{mol^{-1}}$
molar gas constant	R	8.31	$\mathrm{J\ K^{-1}\ mol^{-1}}$
the Boltzmann constant	k	1.38×10^{-23}	$\mathrm{J\ K^{-1}}$
the Stefan constant	σ	5.67×10^{-8}	$\mathrm{W\ m^{-2}\ K^{-4}}$
the Wien constant	α	2.90×10^{-3}	m K
electron rest mass (equivalent to 5.5×10^{-4} u)	m_e	9.11×10^{-31}	kg
electron charge/mass ratio	$\frac{e}{m_e}$	1.76×10^{11}	$\mathrm{C\ kg^{-1}}$
proton rest mass (equivalent to 1.00728 u)	m_p	$1.67(3) \times 10^{-27}$	kg
proton charge/mass ratio	$\frac{e}{m_p}$	9.58×10^{7}	$\mathrm{C\ kg^{-1}}$
neutron rest mass (equivalent to 1.00867 u)	m_n	$1.67(5) \times 10^{-27}$	kg
gravitational field strength	g	9.81	$\mathrm{N\ kg^{-1}}$
acceleration due to gravity	g	9.81	$\mathrm{m\ s^{-2}}$
atomic mass unit (1u is equivalent to 931.5 MeV)	u	1.661×10^{-27}	kg

ALGEBRAIC EQUATION

quadratic equation $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

GEOMETRICAL EQUATIONS

arc length	$= r\theta$
circumference of circle	$= 2\pi r$
area of circle	$= \pi r^2$
curved surface area of cylinder	$= 2\pi rh$
area of sphere	$= 4\pi r^2$
volume of sphere	$= \frac{4}{3}\pi r^3$

ASTRONOMICAL DATA

Body	Mass/kg	Mean radius/m
Sun	1.99×10^{30}	6.96×10^{8}
Earth	5.97×10^{24}	6.37×10^{6}

Particle Physics

Class	Name	Symbol	Rest energy/MeV
photon	photon	γ	0
lepton	neutrino	ν_e	0
		ν_μ	0
	electron	$e^{\pm}$	0.510999
	muon	$\mu^{\pm}$	105.659
mesons	π meson	$\pi^{\pm}$	139.576
		π^0	134.972
	K meson	$K^{\pm}$	493.821
		K^0	497.762
baryons	proton	p	938.257
	neutron	n	939.551

Properties of quarks

antiquarks have opposite signs

Type	Charge	Baryon number	Strangeness
u	$+\frac{2}{3}e$	$+\frac{1}{3}$	0
d	$-\frac{1}{3}e$	$+\frac{1}{3}$	0
s	$-\frac{1}{3}e$	$+\frac{1}{3}$	−1

Properties of Leptons

		Lepton number
Particles:	$e^-, \nu_e; \mu^-, \nu_\mu$	+1
Antiparticles:	$e^+, \overline{\nu_e}, \mu^+, \overline{\nu_\mu}$	−1

Photons and energy levels

photon energy $E = hf = hc/\lambda$

photoelectricity $hf = \phi + E_{k\,(max)}$

energy levels $hf = E_1 - E_2$

de Broglie wavelength $\lambda = \frac{h}{p} = \frac{h}{mv}$

Waves

wave speed $c = f\lambda$ *period* $f = \frac{1}{T}$

first harmonic $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$

fringe spacing $w = \frac{\lambda D}{s}$ *diffraction grating* $d \sin\theta = n\lambda$

refractive index of a substance s, $n = \frac{c}{c_s}$

for two different substances of refractive indices n_1 *and* n_2,

law of refraction $n_1 \sin\theta_1 = n_2 \sin\theta_2$

critical angle $\sin\theta_c = \frac{n_2}{n_1}$ for $n_1 > n_2$

Mechanics

moments moment $= Fd$

velocity and acceleration $v = \frac{\Delta s}{\Delta t}$ $a = \frac{\Delta v}{\Delta t}$

equations of motion $v = u + at$ $s = \left(\frac{u+v}{2}\right)t$

$v^2 = u^2 + 2as$ $s = ut + \frac{at^2}{2}$

force $F = ma$

force $F = \frac{\Delta(mv)}{\Delta t}$

impulse $F\,\Delta t = \Delta(mv)$

work, energy and power $W = F s \cos\theta$

$E_k = \frac{1}{2} m v^2$ $\Delta E_p = mg\Delta h$

$P = \frac{\Delta W}{\Delta t}$, $P = Fv$

$efficiency = \frac{useful\ output\ power}{input\ power}$

Materials

density $\rho = \frac{m}{V}$ *Hooke's law* $F = k\,\Delta L$

Young modulus $= \frac{tensile\ stress}{tensile\ strain}$ *tensile stress* $= \frac{F}{A}$ *tensile strain* $= \frac{\Delta L}{L}$

energy stored $E = \frac{1}{2}F\Delta L$

Electricity

current and pd	$I = \frac{\Delta Q}{\Delta t} \quad V = \frac{W}{Q} \quad R = \frac{V}{I}$
resistivity	$\rho = \frac{RA}{L}$
resistors in series	$R_T = R_1 + R_2 + R_3 + \ldots$
resistors in parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$
power	$P = VI = I^2R = \frac{V^2}{R}$
emf	$\varepsilon = \frac{E}{Q} \qquad \varepsilon = I(R + r)$

Circular motion

magnitude of angular speed	$\omega = \frac{v}{r}$
	$\omega = 2\pi f$
centripetal acceleration	$a = \frac{v^2}{r} = \omega^2 r$
centripetal force	$F = \frac{mv^2}{r} = m\omega^2 r$

Simple harmonic motion

acceleration	$a = -\omega^2 x$
displacement	$x = A\cos(\omega t)$
speed	$v = \pm\omega\sqrt{(A^2 - x^2)}$
maximum speed	$v_{max} = \omega A$
maximum acceleration	$a_{max} = \omega^2 A$
for a mass-spring system	$T = 2\pi\sqrt{\frac{m}{k}}$
for a simple pendulum	$T = 2\pi\sqrt{\frac{l}{g}}$

Thermal physics

energy to change temperature	$Q = mc\Delta\theta$
energy to change state	$Q = ml$
gas law	$pV = nRT$
	$pV = NkT$
kinetic theory model	$pV = \frac{1}{3}Nm(c_{rms})^2$
kinetic energy of gas molecule	$\frac{1}{2}m(c_{rms})^2 = \frac{3}{2}kT = \frac{3RT}{2N_A}$

Gravitational fields

force between two masses	$F = \frac{Gm_1m_2}{r^2}$
gravitational field strength	$g = \frac{F}{m}$
magnitude of gravitational field strength in a radial field	$g = \frac{GM}{r^2}$
work done	$\Delta W = m\Delta V$
gravitational potential	$V = -\frac{GM}{r}$
	$g = -\frac{\Delta V}{\Delta r}$

Electric fields and capacitors

force between two point charges	$F = \frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{r^2}$
force on a charge	$F = EQ$
field strength for a uniform field	$E = \frac{V}{d}$
work done	$\Delta W = Q\Delta V$
field strength for a radial field	$E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$
electric potential	$V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$
	$E = \frac{\Delta V}{\Delta r}$
capacitance	$C = \frac{Q}{V}$
	$C = \frac{A\varepsilon_0\varepsilon_r}{d}$
capacitor energy stored	$E = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$
capacitor charging	$Q = Q_0(1 - e^{-t/RC})$
decay of charge	$Q = Q_0e^{-t/RC}$
time constant	RC

Magnetic fields

force on a current $F = BIl$

force on a moving charge $F = BQv$

magnetic flux $\Phi = BA$

magnetic flux linkage $N\Phi = BAN\cos\theta$

magnitude of induced emf $\varepsilon = N\frac{\Delta\Phi}{\Delta t}$

$N\Phi = BAN\cos\theta$

emf induced in a rotating coil $\varepsilon = BAN\omega\sin\omega t$

alternating current $I_{rms} = \frac{I_0}{\sqrt{2}}$ $V_{rms} = \frac{V_0}{\sqrt{2}}$

transformer equations $\frac{N_s}{N_p} = \frac{V_s}{V_p}$

$efficiency = \frac{I_s V_s}{I_p V_p}$

Nuclear physics

the inverse square law for γ radiation $I = \frac{k}{x^2}$

radioactive decay $\frac{\Delta N}{\Delta t} = -\lambda N$, $N = N_0 e^{-\lambda t}$

activity $A = \lambda N$

half-life $T_{½} = \frac{\ln 2}{\lambda}$

nuclear radius $R = R_0 A^{1/3}$

energy-mass equation $E = mc^2$

OPTIONS

Astrophysics

1 astronomical unit = 1.50×10^{11} m

1 light year = 9.46×10^{15} m

1 parsec = 206265 AU = 3.08×10^{16} m
= 3.26 light year

Hubble constant, $H = 65\ \text{km s}^{-1}\ \text{Mpc}^{-1}$

$M = \frac{\text{angle subtended by image at eye}}{\text{angle subtended by object at unaided eye}}$

in normal adjustment $M = \frac{f_0}{f_e}$

Rayleigh criterion $\theta \approx \frac{\lambda}{D}$

magnitude equation $m - M = 5\log\frac{d}{10}$

Wien's law $\lambda_{max} T = 2.9 \times 10^{-3}\ \text{m K}$

Stefan's law $P = \sigma A T^4$

Schwarzschild radius $R_s \approx \frac{2GM}{c^2}$

Doppler shift for v << c $\frac{\Delta f}{f} = -\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$

red shift $z = -\frac{v}{c}$

Hubble's law $v = Hd$

Medical physics

lens equations $P = \frac{1}{f}$

$m = \frac{v}{u}$

$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

threshold of hearing $I_0 = 1.0 \times 10^{-12}\ \text{W m}^{-2}$

intensity level $\text{intensity level} = 10\log\frac{I}{I_0}$

absorption $I = I_0 e^{-\mu x}$

$\mu_m = \frac{\mu}{\rho}$

ultrasound imaging $Z = p\,c$

$\frac{I_r}{I_i} = \left(\frac{Z_2 - Z_1}{Z_2 + Z_1}\right)^2$

half-lives $\frac{1}{T_E} = \frac{1}{T_B} + \frac{1}{T_P}$

Engineering physics

moment of inertia $I = \Sigma mr^2$

angular kinetic energy $E_k = \frac{1}{2} I\omega^2$

equations of angular motion

$\omega_2 = \omega_1 + \alpha t$

$\omega_2^2 = \omega_1^2 + 2\alpha\theta$

$\theta = \omega_1 t + \frac{\alpha t^2}{2}$

$\theta = \frac{(\omega_1 + \omega_2)\, t}{2}$

torque $T = I\alpha$

$T = Fr$

angular momentum $\text{angular momentum} = I\omega$

angular impulse $T\Delta t = \Delta(I\omega)$

work done $W = T\theta$

power $P = T\omega$

thermodynamics $Q = \Delta U + W$

$W = p\Delta V$

adiabatic change $pV^{\gamma} = \text{constant}$

isothermal change $pV = \text{constant}$

heat engines

$$\textit{efficiency} = \frac{W}{Q_H} = \frac{Q_H - Q_C}{Q_H}$$

$$\textit{maximum theoretical efficiency} = \frac{T_H - T_C}{T_H}$$

work done per cycle = area of loop

input power = calorific value × fuel flow rate

indicated power = (*area of* $p - V$ *loop*) × (*number of cycles per second*) × (*number of cylinders*)

output or brake power $P = T\omega$

friction power = indicated power – brake power

heat pumps and refrigerators

refrigerator: $COP_{ref} = \frac{Q_C}{W} = \frac{Q_C}{Q_H - Q_C}$

heat pump: $COP_{hp} = \frac{Q_H}{W} = \frac{Q_H}{Q_H - Q_C}$

Turning points in physics

electrons in fields $F = \frac{eV}{d}$

$F = Bev$

$r = \frac{mv}{Be}$

$\frac{1}{2} mv^2 = eV$

Millikan's experiment $\frac{QV}{d} = mg$

$F = 6\pi\eta rv$

Maxwell's formula $c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$

$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2meV}}$

special relativity $t = \frac{t_0}{\sqrt{1 - \frac{v^2}{c^2}}}$

$l = l_0 \sqrt{1 - \frac{v^2}{c^2}}$

$E = mc^2 = \frac{m_0 c^2}{\sqrt{1 - \frac{v^2}{c^2}}}$

Electronics

resonant frequency $f_0 = \frac{1}{2\pi\sqrt{LC}}$

Q-factor $Q = \frac{f_0}{f_B}$

operational amplifiers: open loop $V_{out} = A_{OL}(V_+ - V_-)$

inverting amplifier $\frac{V_{out}}{V_{in}} = -\frac{R_f}{R_{in}}$

non-inverting amplifier $\frac{V_{out}}{V_{in}} = 1 + \frac{R_f}{R_1}$

summing amplifier $V_{out} = -R_f\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} + \cdots\right)$

difference amplifier $V_{out} = (V_+ - V_-)\frac{R_f}{R_1}$

Bandwidth requirement:

for AM $bandwidth = 2f_M$

for FM $bandwidth = 2(\Delta f + f_M)$

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This document has been produced for educational purposes only.

This document has been produced for the AQA A Level Physics Specification.

Student Voice

If you when using this document, you believe there is an improvement to made, please state this in the space below….

Only constructive and reasoned feedback will be considered.