Accredited

A Level Physics A
H556/03 Unified physics
Sample Question Paper

Date – Morning/Afternoon
Version 2.0

Time allowed: 1 hour 30 minutes

You must have:
• the Data, Formulae and Relationships Booklet

You may use:
• a scientific or graphical calculator

First name	
Last name	

Centre number						Candidate number				

INSTRUCTIONS
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Where appropriate, your answers should be supported with working. Marks may be given for a correct method even if the answer is incorrect.
- Write your answer to each question in the space provided.
- Additional paper may be used if required but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.

INFORMATION
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended responses will be assessed in questions marked with an asterisk (*).
- This document consists of **20** pages.

Answer **all** the questions

1 This question is about the operation of an electrically powered shower designed by an electrical firm.

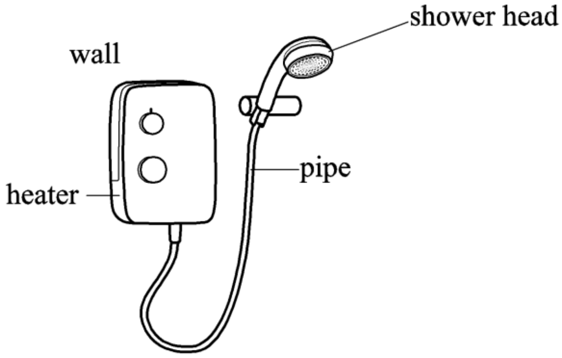

Fig.1.1

(a) Water moves at constant speed through a pipe of cross-sectional area 7.5×10^{-5} m^2 to a shower head shown in **Fig. 1.1.** The maximum mass of water which flows per second is 0.070 kg s^{-1}.

(i) Show that the maximum speed of the water in the pipe is about 0.9 m s^{-1}.

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

[2]

(ii) The total cross-sectional area of the holes in the shower head is one quarter that of the pipe. Calculate the maximum speed of the water as it leaves the shower head.

maximum speed = ……………………. m s^{-1} **[1]**

(iii) Calculate the magnitude of the force caused by the accelerating water on the shower head.

force = ……………………. N **[2]**

(iv) Draw on to **Fig. 1.1** the direction of the force in **(iii)**. **[1]**

(b) The water enters the heater at a temperature of 14 °C. At the maximum flow rate of 0.070 kg s^{-1}, the water leaves the shower head at a temperature of 30 °C.

Calculate the rate at which energy is transferred to the water. Give a suitable unit for your answer.

specific heat capacity of water = 4200 J kg^{-1} K^{-1}

rate of energy transfer = ……………………unit …..…. **[3]**

Question 2 begins on page 5.

BLANK PAGE

2 A motorcyclist riding on a level track is told to stop via a radio microphone in his helmet. The distance *d* travelled from this instant and the initial speed *v* are measured from a video recording.

Fig. 2.1

A student is investigating how the stopping distance of a motorcycle with high-performance brakes varies with the initial speed.

(a) Explain why the student predicts that *v* and *d* are related by the equation

$$d = \frac{v^2}{2a} + vt$$

where *a* is the magnitude of the deceleration of the motorcycle and *t* is the thinking time of the rider.

[1]

(b) The student decides to plot a graph of $\frac{d}{v}$ on the *y*-axis against *v* on the *x*-axis.

Explain why this is a sensible decision.

………..

……….…………………………………………………………………………………………………….

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

(c) The measured values of *v* and *d* are given in the table.

***v* / m s⁻¹**	***d* / m**	$\frac{d}{v}$ **/ s**
10 ± 1	13.0 ± 0.5	
15 ± 1	24.5 ± 0.5	1.63 ± 0.14
20 ± 1	39.5 ± 0.5	1.98 ± 0.12
25 ± 1	57.5 ± 0.5	2.30 ± 0.11
30 ± 1	79.0 ± 0.5	2.63 ± 0.10
35 ± 1	103.0 ± 0.5	2.94 ± 0.09

(i) Complete the missing value of $\frac{d}{v}$ in the table, including the absolute uncertainties. Use the data to complete the graph of **Fig. 2.2.** Four of the points have been plotted for you.

[2]

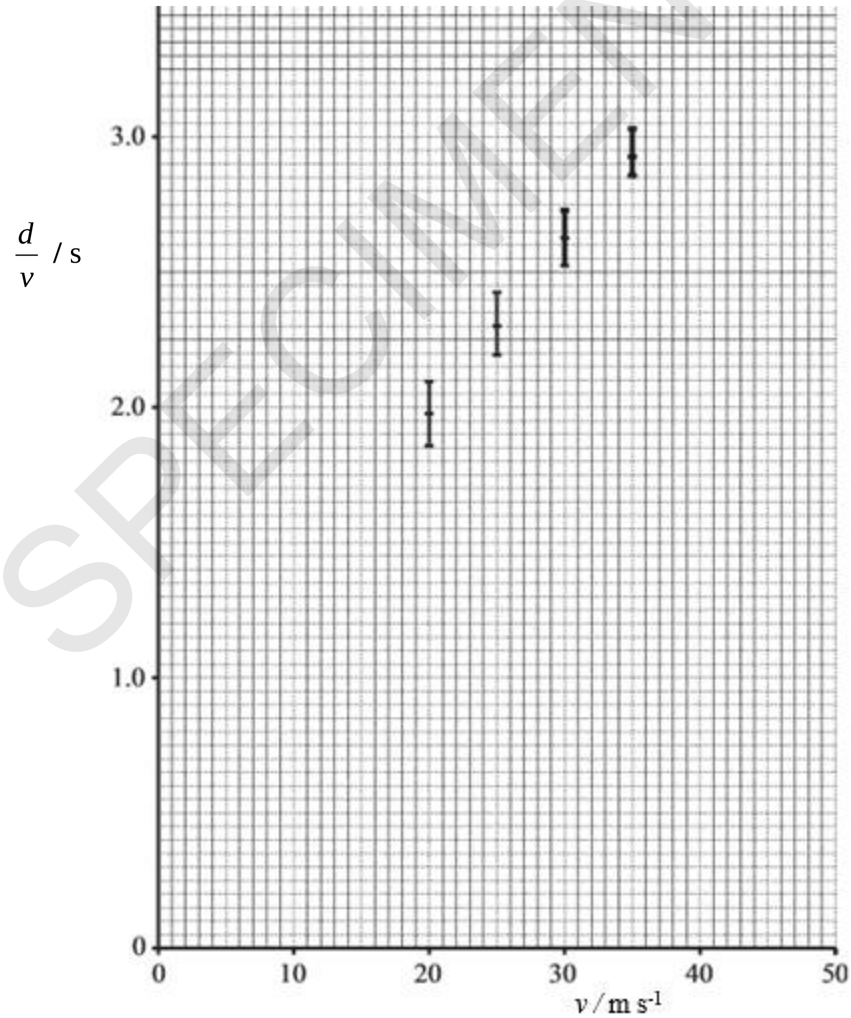

Fig. 2.2

(ii) Use **Fig. 2.2** to determine the values of a and t, including their absolute uncertainties.

a = ... ± .... m s^{-2}

t = ... ± .... s

[4]

(d) It was suspected that the method used to determine the distance d included a zero error. The distance recorded by the student was **larger** than it should have been.

Discuss how this would affect the actual value of t obtained in **(c).**

....

....

....

....

.... **[3]**

3 **(a)** Some students are asked to use the laboratory 28 mm microwave transmitter **T** and receiver **R** apparatus to design a demonstration to illustrate the principle of a radar speed measuring device.

In **Fig. 3.1**, a movable hardboard sheet **H**, which is a partial reflector of microwaves, is placed in front of the metal sheet **M**, which is fixed.

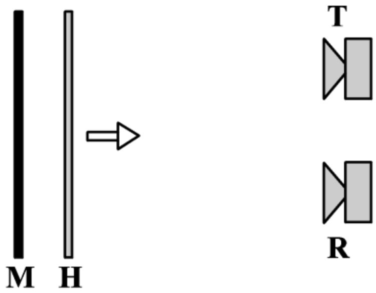

Fig. 3.1

The students expect the detected signal to change between maximum and minimum intensity when sheet **H** moves a distance of 7 mm towards the receiver.

When the detected signal is passed through an audio amplifier to a loudspeaker a sound should be heard. They claim that when the sheet moves at 2.8 m s^{-1} the frequency heard should be 200 Hz. You are to evaluate whether their experiment is feasible and whether their conclusions are correct.

(i) Explain why the detected signal strength should vary and discuss what factors will determine whether the difference between maxima and minima can be detected.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………… **[6]**

(ii) Justify the students' predictions of 7 mm between maxima and minima and a sound at 200 Hz for a speed of 2.8 m s^{-1}.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

………………………………………………………………………………………………… **[3]**

(b) A police speed detector gun works by a different principle. Two short pulses of electromagnetic radiation, a time t_0 apart, are 'fired' at the front of the vehicle which is moving directly towards the gun. The reflected pulses are received at a time t apart. A digital readout on the top of the gun displays the speed of the vehicle.

In the space below, by considering how far the vehicle moves in time t_0, show that the speed of the vehicle is given by the expression

$$v = \frac{c(t_0 - t)}{2t_0}$$

where c is the speed of light.

[3]

4 Civil engineers are designing a floating platform to be used at sea. **Fig. 4.1** shows a model for one section of this platform, a sealed metal tube of uniform cross-sectional area, loaded with small pieces of lead, floating upright in equilibrium in water.

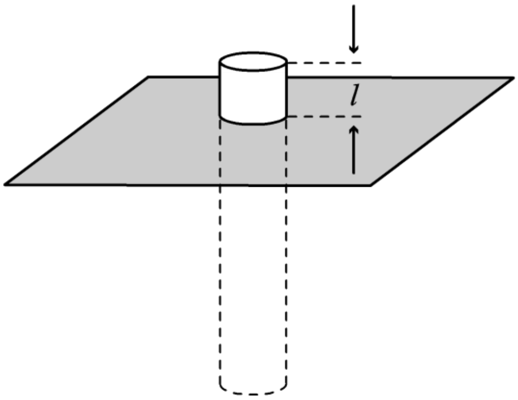

Fig. 4.1

(a) The tube has length 300 mm and diameter 50 mm. The total mass of the lead and tube is 0.50 kg. Show that the length *l* of tube above the surface is more than 40 mm.

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

[3]

(b) When the tube is pushed down a small amount into the water and released it moves vertically up and down with simple harmonic motion. The period of these oscillations which quickly die away is about one second.

The oscillations of the tube can be maintained over a range of low frequencies by using a flexible link to a simple harmonic oscillator.

Fig. 4.2 shows a graph of amplitude of vertical oscillations of the tube against frequency obtained from this experiment.

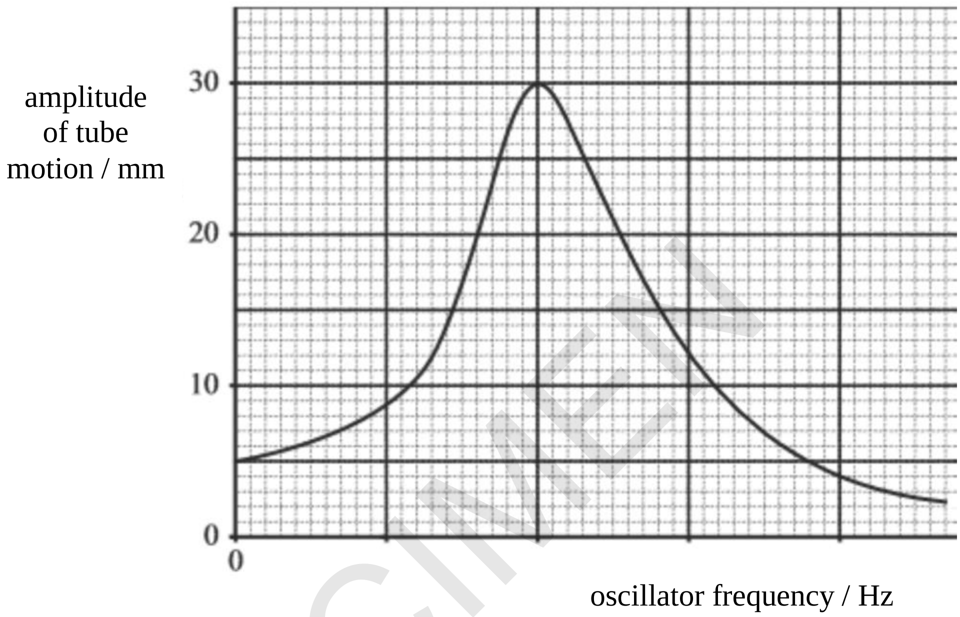

Fig. 4.2

(i) Use information from **Fig. 4.2** to state the amplitude of the motion of the oscillator.

amplitude = ………..………. mm **[1]**

(ii) Add a suitable scale to the frequency axis of **Fig. 4.2**. **[1]**

(iii) The experiment is repeated in a much more viscous liquid such as motor oil.
On **Fig. 4.2** sketch the graph that you would predict from this experiment. **[2]**

5 (a)* **Fig. 5.1** shows a simple a.c. generator being tested by electrical engineers.

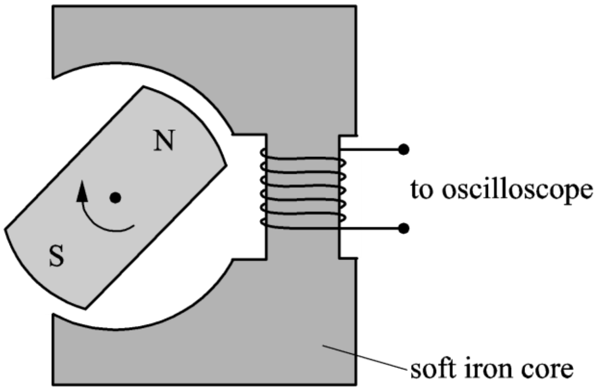

Fig. 5.1

It consists of a magnet, on the shaft of a **variable speed** motor, being rotated inside a cavity in a soft iron core. The output from the coil, wound on the iron core, is connected to an oscilloscope. The grid of **Fig. 5.2** shows a typical output voltage which would be displayed on the oscilloscope screen.

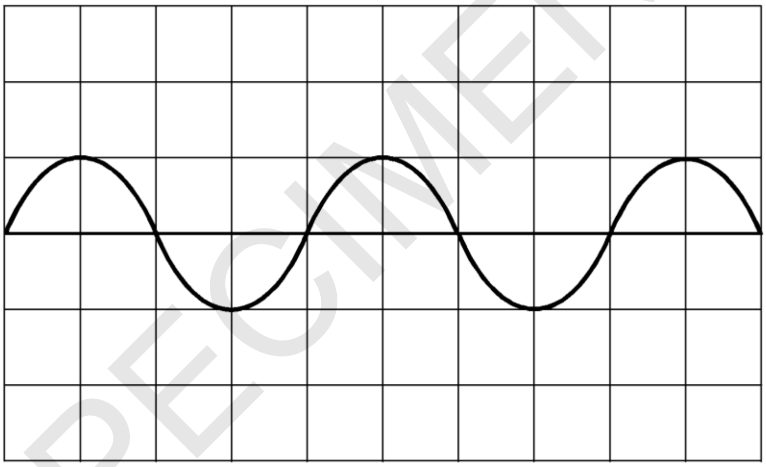

Fig. 5.2

According to Faraday's law the e.m.f. induced is directly proportional to the rate of change of flux linkage. In the context of this experiment, the maximum e.m.f. induced is directly proportional to the frequency of rotation of the magnet.

Use the apparatus above to plan an experiment to validate Faraday's law of electromagnetic induction. In your description include how the data is collected and analysed. **[6]**

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………..

Additional answer space if required.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………..

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

(b) **Fig. 5.3** shows the poles of a powerful electromagnet producing a uniform field in the gap between them. The dimension of each pole is 0.10 m by 0.080 m. There is no field outside the gap. A circular coil of 80 turns is placed so that it encloses the total flux of the magnetic field.

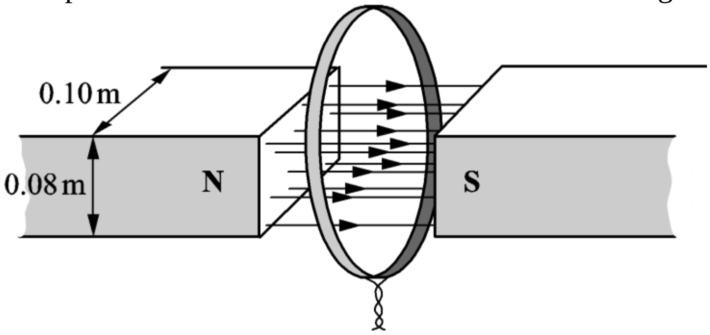

Fig. 5.3

(i) The current in the electromagnet is reduced so that the field falls linearly from 0.20 T to zero in 5.0 s.

Calculate the initial flux in the gap and hence the e.m.f. generated in the coil during this time.

induced e.m.f. = ………………… V **[2]**

(ii) The coil is part of a circuit of total resistance *R* so that a current is generated in the circuit while the field is collapsing.

Draw on the coil in **Fig. 5.3** the direction of this induced current.

State how you applied the laws of electromagnetic induction to deduce the direction of this current.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………………… **[2]**

BLANK PAGE

Question 6 begins on page 16

6 An astronomer uses a spectrometer and diffraction grating to view a hydrogen emission spectrum from a star. The light is incident normally on the grating.

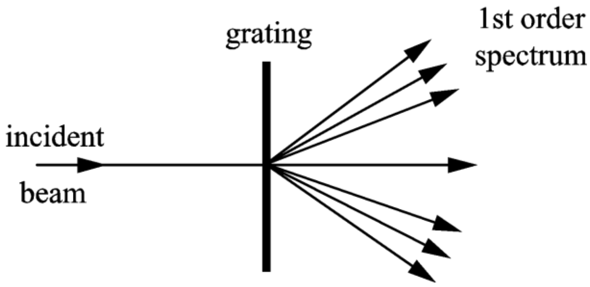

Fig. 6.1

(a) First order diffraction maxima are observed at angles of 12.5°, 14.0° and 19.0° to the direction of the incident light as shown in **Fig. 6.1.**
Two of the wavelengths are 4.33×10^{-7} m and 4.84×10^{-7} m.
Calculate the wavelength of the third line.

wavelength = …………………. m **[2]**

(b) In order to increase the accuracy of the values for wavelength, the student decides to look for higher order diffraction maxima.

(i) State how this increases the accuracy.

……………………………………………………………………………………………….

…………………………………………………………………………………………… **[1]**

(ii) Calculate how many orders n can be observed for the shorter wavelength given in **(a)**.

n = ………………… **[2]**

(c) These three emission lines all arise from transitions to the same final energy level. The part of the energy level diagram of hydrogen relevant to these transitions is shown in **Fig. 6.2**.

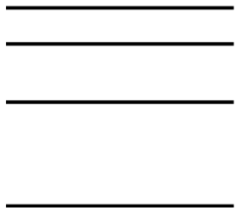

Fig. 6.2

(i) Draw lines between the energy levels to indicate the transitions which cause the three emission lines and label them with their wavelengths. **[1]**

(ii) There are other possible transitions between the energy levels shown in **Fig. 6.2**. The least energetic of these produces photons of 4.8×10^{-20} J.

Calculate the wavelength of these photons.

State in which region of the electromagnetic spectrum this wavelength is found.

wavelength ……………………………..m

region: ……………………………………………………

[3]

7 **(a)*** Describe the processes of fission and fusion of nuclei stating one similarity and one difference between the two processes. Describe the conditions required for each process to occur in a sustained manner. **[6]**

Additional answer space if required.

....

....

....

....

(b) Uranium-235 is used in many fission reactors as fuel and fusion reactors are still at an experimental stage.

(i) State one major disadvantage of having fission reactors.

………………………………………………………………………………………………

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

(ii) The fission of a uranium-235 nucleus releases about 200 MeV of energy, whereas the fusion of four hydrogen-1 nuclei releases about 28 MeV.
At first sight it would appear that fusion would produce less energy than fission. However the energy released in the fission of one kilogramme of uranium-235 is about eight times less than the energy released in the fusion of one kilogramme of hydrogen-1.

Explain this by considering the initial number of particles in one kilogramme of each.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

[4]

END OF QUESTION PAPER

Oxford Cambridge and RSA

…day June 20X –Morning/Afternoon

A Level Physics A

H556/03 Unified physics

SAMPLE MARK SCHEME

Duration: 1 hour 30 minutes

MAXIMUM MARK 70

This document consists of 16 pages

MARKING INSTRUCTIONS

PREPARATION FOR MARKING

SCORIS

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *scoris assessor Online Training*; *OCR Essential Guide to Marking*.

2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are posted on the RM Cambridge Assessment Support Portal http://www.rm.com/support/ca

3. Log-in to scoris and mark the **required number** of practice responses ("scripts") and the **required number** of standardisation responses.

   YOU MUST MARK 10 PRACTICE AND 10 STANDARDISATION RESPONSES BEFORE YOU CAN BE APPROVED TO MARK LIVE SCRIPTS.

MARKING

1. Mark strictly to the mark scheme.

2. Marks awarded must relate directly to the marking criteria.

3. The schedule of dates is very important. It is essential that you meet the scoris 50% and 100% (traditional 50% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.

4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the scoris messaging system.

5. Work crossed out:

   a. where a candidate crosses out an answer and provides an alternative response, the crossed out response is not marked and gains no marks

   b. if a candidate crosses out an answer to a whole question and makes no second attempt, and if the inclusion of the answer does not cause a rubric infringement, the assessor should attempt to mark the crossed out answer and award marks appropriately.

6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there then add a tick to confirm that the work has been seen.

7. There is a NR (No Response) option. Award NR (No Response):

   - if there is nothing written at all in the answer space

   - OR if there is a comment which does not in any way relate to the question (e.g. 'can't do', 'don't know')

   - OR if there is a mark (e.g. a dash, a question mark) which isn't an attempt at the question.

   Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).

8. The scoris **comments box** is used by your Team Leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**

   If you have any questions or comments for your Team Leader, use the phone, the scoris messaging system, or email.

9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10. For answers marked by levels of response:

- Read through the whole answer from start to finish.

- Decide the level that **best fits** the answer – match the quality of the answer to the closest level descriptor.

- To select a mark within the level, consider the following:

Higher mark: A good match to main point, including communication statement (in italics), award the higher mark in the level
Lower mark: Some aspects of level matches but key omissions in main point or communication statement (in italics), award lower mark in the level.

Level of response questions on this paper are **5(a)** and **7(a)**.

11. **Annotations**

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

12. **Subject-specific Marking Instructions**

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

CATEGORISATION OF MARKS

The marking schemes categorise marks on the MACB scheme.

B marks: These are awarded as independent marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answers.

M marks: These are method marks upon which **A**-marks (accuracy marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answers. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.

C marks: These are compensatory method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the **C**-mark is given.

A marks: These are accuracy or answer marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.

Note about significant figures:

If the data given in a question is to 2 sf, then allow to 2 or more significant figures.
If an answer is given to fewer than 2 sf, then penalise once only in the entire paper.
Any exception to this rule will be mentioned in the Additional Guidance.

Question			Answer	Marks	Guidance
1	(a)	(i)	$\rho = m/V = m/Av$; so $m = A\rho v$ $7.5 \times 10^{-5} \times 1000 \times v = 0.070$ giving $v = 0.93$ (m s^{-1})	**C1** **A1** **A0**	
		(ii)	3.7 (m s^{-1})	**A1**	Accept 3.72
		(iii)	$F = \Delta(mv)/\Delta t = 0.070 \times (3.72 - 0.93)$ $F = 0.195$ (N)	**C1** **A1**	**ecf(a)(ii)** accept 0.19 or 0.2(0)
		(iv)	arrow into the shower head perpendicular to its face.	**B1**	award mark for a reasonable attempt.
	(b)		$P = (m/t)c\theta = 0.070 \times 4200 \times (30 - 14)$ $= 4700$ unit = W or J s^{-1}	**C1** **A1** **B1**	 or 4.7 **allow** kW if consistent with the value for P.
			Total	**9**	

Question			Answer	Marks	Guidance
2	(a)		for thinking time t rider moves s = vt for (constant) deceleration from v to 0, $v^2 = 2as$ so total s = d = $v^2/2a + vt$	**B1**	
	(b)		using y = mx + c d/v =v/2a + t gives an equation resulting in a straight line graph as a and t are constants.	**B1** **B1**	
	(c)	(i)	1.30 ± 0.18 entered in table two points correctly plotted on graph with error bars Line of best fit; If points are plotted correctly then lower end of line should pass between (9.5, 1.3) and (10.5, 1.3) **and** upper end of line should pass between (34.0, 2.9) and (35.5, 2.9). Worst acceptable straight line.	**B1** **B1**	allow ± 0.2 to ± 0.16 **ecf** value and error bar of first point **allow ecf** from points plotted incorrectly. steepest or shallowest possible line that passes through <u>all</u> the error bars; should pass from top of top error bar to bottom of bottom error bar **or** bottom of top error bar to top of bottom error bar.
		(ii)	gradient of best fit line. should be about 0.065 a = 1/(2 x gradient) giving a = 7.7 (m s^{-2}) *y*-intercept of best fit line; should be about 0.65 t = *y*-intercept so should be about 0.65 (s) uncertainty in gradient; should be about 0.010 to 0.012 giving uncertainty in a to be about ± 1.1 to ± 1.2 uncertainty in *y*-intercept and t should be about ± 0.3	**B1** **B1** **B1** **B1**	**allow ecf** values from graph in all values below allow 7.3 to 7.7 difference in worst gradient and gradient. difference in worst *y*-intercept and *y*-intercept both uncertainties correct for final mark.
	(d)		actual d/v values will be lower. so the y-intercept will be lower. hence the actual t (= y-intercept) will be smaller.	**M1** **M1** **A1**	
			Total	**12**	

Question			Answer	Marks	Guidance
3	(a)	(i)	reflected signals from M (amplitude a) and H (amplitude A) are added at the receiver path difference between moving reflected signal and fixed reflected signal varies between 0 and λ sum of the displacements at the receiver varies between A + a and A – a any 3 from • signal from M is attenuated because travels further; • absorbed passing twice through H or some reflected at the back of H • signal from H will increase as H moves towards the detector • if A is much greater than a then variation will be difficult to detect.	B1 B1 B1 B1x3	**accept** interfere. **or** phase difference between the two received signals varies between 0 and 2π allow absorbed or similar word for attenuated. allow full credit for discussion in terms of $(A^2 - a^2)/(A^2 + a^2)$.
		(ii)	detected signal varies between max and min for λ/4(= 7.0 mm) as path difference is λ/2 every λ/2 (14 mm) moved, the signal goes through one cycle so for 200 Hz must go through 100 λ in 1 s = 2.8 (m s^{-1}).	B1 B1 B1	
	(b)		in time t_o car moves vt_o path lengths travelled by the two pulses differ by $c(t_o - t)$ but this is twice the distance the car has moved as it is a reflected signal so $2vt_o = c(t_o - t)$.	B1 M1 A1 A0	justified e.g. best solved by imagining first pulse takes time T_o and second time T and then $T_o - T = t_o - t$ and/or drawing a space diagram.
			Total	**12**	

Question			Answer	Marks	Guidance
4	(a)		W of tube = upthrust (caused by submerged length) = A(0.30 – l) ρg W = 0.5 x 9.8 = 4.9 = π(2.5 x 10^{-2})^2 x (0.3 – l) x1.0 x 10^3 x 9.8 = 19.2 (0.30 – l) 0.30 – l = 0.255 giving l = 0.045 m =45 (mm).	**B1** **C1** **A1**	Archimedes principle expressed in some form.
	(b)	(i)	5 (mm).	**A1**	
		(ii)	1.0 mark on scale at peak of curve.	**B1**	minimum requirement for mark: 0 to 3 Hz marked at 1 Hz intervals along axis.
		(iii)	approx. same (or slightly lower) resonance frequency. smaller amplitude/broader peak *but curves must not cross* and passes through (0, 5 mm).	**B1** **B1**	
			Total	**7**	

Question			Answer	Marks	Guidance
5	(a)*		**Level 3 (5–6 marks)** At least P1 and P2 M1, M2, M4 and M5 At least A2 and A3 At least C1 and C2 *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** At least P1 M1, M4 and M2 or M5 At least A3 At least C1 *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* **Level 1 (1–2 marks)** At least P1 At least M1 and M4 At least A3 At least C1 *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** No response or no response worthy of credit.	**B1 x 6**	**plan P** 1. vary speed of rotation of magnet using motor control 2. expect to see amplitude of signal increase and period of waveform decrease 3. measure (maximum) e.m.f V and period T for each setting from oscilloscope screen. **measurements M** 1. maximum e.m.f. 2. measured from peak to peak distance on graticule 3. and using V/cm scale setting 4. period of rotation 5. measured along t-axis of graticule 6. and using s/cm time base setting. **analysis A** 1. record table of V, T 2. and (calculate and record) f = 1/T. 3. plot graph of V against f **conclusions C** 1. a straight line graph 2. through origin 3. is required to validate Faraday's law.
	(b)	(i)	flux = BA = 0.20 x 0.10 x 0.080 = 0.0016 (Wb)	**B1**	

Question			Answer	Marks	Guidance
			induced emf = NBA/t = 80 x 0.0016/5 = 0.026 (V)	**B1**	
		(ii)	Lenz's law indicates that current must try to maintain the field as it collapses **or** current must produce same field as magnet to try to maintain the field. current is anticlockwise in coil as viewed from S pole.	**M1** **A1**	
			Total	**10**	

Question			Answer	Marks	Guidance
6	(a)		$\lambda_1 = d \sin 12.5 = 4.33 \times 10^{-7}$ m giving $1/d = 5 \times 10^5$ or $d = 2 \times 10^{-6}$ $\lambda_3 = \sin 19.0/5 \times 10^5 = 6.51 \times 10^{-7}$ (m) **or** $\lambda_1 = d \sin 12.5 = 4.33 \times 10^{-7}$ and $\lambda_3 = d \sin 19.0$ so $\lambda_3 = 4.33 \times 10^{-7} \sin 19.0/\sin 12.5 = 6.51 \times 10^{-7}$ (m)	**C1** **A1**	or $\lambda_2 = d \sin 14.0 = 4.84 \times 10^{-7}$ (m) or use $\lambda_2 = d \sin 14.0 = 4.84 \times 10^{-7}$ m $\sin 19.0/\sin 12.5 = 0.326/0.216 = 1.50$
	(b)	(i)	the uncertainty in the measurement of angle is the same for all angles and the bigger the angle measured the smaller the % error	**B1**	
		(ii)	$n_{max} = d \sin 90$ $= 1/(5 \times 10^5 \times 4.33 \times 10^{-7}) = 4.6$ but n is an integer so n = 4	**C1** **A1**	
	(c)	(i)	3 downward arrows correctly labelled.	**B1**	longest being 4.33×10^{-7} (m)
		(ii)	$\Delta E = hc/\lambda$ $\lambda = 6.63 \times 10^{-34} \times 3 \times 10^8/ 4.8 \times 10^{-20} = 4.1(4) \times 10^{-6}$ (m) region: infra red	**C1** **A1** **B1**	 **allow** ecf if wavelength calculation incorrect.
			Total	**9**	

Question			Answer	Marks	Guidance
7	(a)*		**Level 3 (5–6 marks)** All of B correct. One of S and one of D stated. C fully described. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** B partially given. S and D given but one not clear. C lacks detail. *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* **Level 1 (1–2 marks)** B poor and incomplete. Only S or D given. C not mentioned or very inadequate. *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.* **0 marks** No response or no response worthy of credit.	**B1** **x 6**	**basic description (B)** *1. fission:* neutron is absorbed by the nucleus causing it to split into two (major) fragments and several/two/three neutrons 2. *fusion:* two light nuclei (moving rapidly enough) overcome the Coulomb repulsion between them fuse. **similarity (S)** 1. release of energy 2. total (rest) mass decrease 3. 'increase' in binding energy 4. conservation of charge/mass-energy. **difference (D)** 1. cold, hot 2. heavy, light nuclei 3. large (200 MeV), small (30 MeV) energy release per reaction. **conditions (C)** 1. fission rate can be varied/controlled by absorbing and or slowing released neutrons in reactor where chain reaction is occurring 2. fusion needs a very hot and sufficiently dense and plentiful plasma for random fusion collisions to occur, e.g. inside Sun/star.

Question			Answer	Marks	Guidance
	(b)	(i)	Fission reactors produce radioactive by-products which affect future generations and the environment in terms of possible contamination/exposure to humans and animals.	B1	
		(ii)	No of particles in 1000g U =1000/235 x 6.02 x 10^{23} =2.56 x 10^{24} No of reactions for U = 2.56 x 10^{24} Energy from U =2.56 x 10^{24} x 200 = 5.12 x 10^{26} MeV No of particles in 1000g H = 6.02 x 10^{26} No of reactions = 6.02 x 10^{26}/4 Energy from H = 6.02 x 10^{26}/4 x 28 = 42.14 x 10^{26} MeV Hence energy 42/5 = 8.2 times higher *second method* 235 g of U and 4 g of H/He contain 1 mole of atoms there are 4.26 moles of U and 250 moles of He so at least 58 times as many energy releases in fusion ratio of energies is only 7 fold in favour of U therefore 58/7 times as much energy released by 1 kg of H *similar alternative argument,* e.g. For U each nucleon 'provides' 0.85 MeV For H each nucleon 'provides' 7 MeV (Approx) same number of nucleons per kg of U or H so 8.2 times as much energy from H	B1 B1 B1 B1 **or** B1 B1 B1 B1 **or** B1 B1 B1 B1	Appreciate that the key to the answer is the difference in numbers of atoms/nuclei **or** equal number of nucleons involved scores one mark if nothing else achieved.
			Total	**11**	

Summary of updates

Date	Version	Change
January 2019	2.0	Minor accessibility changes to the paper: i) Additional answer lines linked to Level of Response questions ii) One addition to the rubric clarifying the general rule that working should be shown for any calculation questions