OCR
Oxford Cambridge and RSA

Practice paper – Set 2

H 556/01 ***Modelling physics***

MARK SCHEME

Duration: 2 hours 15 minutes

MAXIMUM MARK 100

Version - Final

This document consists of 19 pages

MARKING INSTRUCTIONS

PREPARATION FOR MARKING

RM ASSESSOR

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM 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 RM Assessor and mark the **required number** of practice responses ("scripts") and the **required number** of standardisation responses.

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 RM Assessor 50% and 100% (traditional 40% 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 or the RM Assessor messaging system, or by email.

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 RM Assessor **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 RM Assessor messaging system, or e-mail.

9. Assistant Examiners will send a brief report on the performance of candidates directly to the Principal Examiner (PE) by the end of the marking period. The Assistant Examiner’s Report Form (AERF) can be found on the RM Cambridge Assessment Support Portal. Your report should contain notes on particular strength 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.

11. Annotations available in RM Assessor

Annotation	Meaning
BOD	Benefit of doubt given
CON	Contradiction
✗	Incorrect response
ECF	Error carried forward
L1	Level 1
L2	Level 2
L3	Level 3
TE	Transcription error
NBOD	Benefit of doubt not given
POT	Power of 10 error
^	Omission mark
SF	Error in number of significant figures
✓	Correct response
?	Wrong physics or equation

12. Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
/	alternative and acceptable answers for the same marking point
reject	Answers which are not worthy of credit
not	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

13. **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 Marker Guide RM Assessor Document on the Examiners and Assessors Communications page on the OCR website. If you are examining for the first time, please ensure that you have completed *OCR's Essential Guide to Marking Part 1*.

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.

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.

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.

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 Guidance.

SECTION A

Question	Answer	Marks	Guidance
1	A	1	
2	D	1	
3	C	1	
4	C	1	
5	B	1	
6	A	1	
7	C	1	
8	A	1	
9	B	1	
10	D	1	
11	B	1	
12	C	1	
13	B	1	
14	A	1	
15	B	1	
	Total	15	

SECTION B

Question			Answer	Marks	Guidance
16	(a)	(i)	$g = \frac{2s}{t^2}$ / $g = \frac{2\times 1.200}{0.50^2}$ g = 9.6 (m s^{-2})	C1 A1	
	(a)	(ii)	(% uncertainty in s) = 0.08 % or (% uncertainty in t) = 4.00 % % uncertainty in g = $\left((2 \times 4.00) + 0.08\right)$ % uncertainty in g = 8.08 (%)	C1 A1	**Allow** 8.1% or 8 %
	(b)		The steel ball not released straight away (because of the residual magnetism of the electromagnet) / The trapdoor does not open immediately. (AW) Increase distance of fall.	B1 B1	

	(c)*		**Level 3 (5–6 marks)** Clear procedure, measurements and analysis. *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)** Some procedure, some measurements and some analysis. *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)** Limited procedure and limited measurements or limited analysis. *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× 6**	**Indicative scientific points may include:** **Procedure** • Release ball and start timer. • Stop timer when ball reaches bottom of ramp. • Make distance as long as possible to reduce % uncertainty in timing. • Repeat measurement for t to get an average. • Mark the ramp at the set distance d to ensure release point is accurate. • Use a release mechanism to release ball. • Ensure the ball is not pushed when released. **Measurements** • Measure θ using protractor or calculate θ using trigonometry and correct distances. • Measure t using a stopwatch. • Measure the distance d using a ruler, from the leading-edge of the ball to the bottom of the ramp. **Analysis** • Plot a correct graph; e.g. d against t^2. • Gradient of best fit straight line determined. • Correct determination of g from the gradient.
			Total	**12**	

Question			Answer	Marks	Guidance
17	(a)		The extension of each spring is halved because the force in each spring is halved. (Hence the force constant is $2k$.)	B1	**Allow** F = kx, x is halved for the same F, hence k doubles.
	(b)	(i)	Missing data point and error bar plotted correctly.	B1	**Allow** ½ square tolerance.
		(ii)	Force measured by pulling back plate with a newton-meter. Extension measured with a ruler (placed close to the transparent plastic tube).	B1 B1	
		(iii)	Best fit line drawn correctly and gradient determined correctly. Worst fit line drawn correctly and its gradient determined correctly. $2k = 50$ (N m^{-1}), therefore $k = 25$ (N m^{-1}) Absolute uncertainty determined correctly.	B1 B1 B1 B1	**Ignore** POT for this mark; gradient = 50 ± 4 (N m^{-1}) **Note**: The line must have a greater/smaller gradient than the best fit line and must pass through all the error bars. **Ignore** POT for this mark. Possible ECF. Possible ECF within calculation.
		(iv)	$F \propto x$ / straight line passing through the <u>origin</u>.	B1	
		(v)	energy stored = $\frac{1}{2} \times 50 \times 0.12^2$ $\frac{1}{2} \times 50 \times 0.12^2 = \frac{1}{2} \times 0.39 \times v^2$ $v = 1.4$ (m s^{-1})	C1 C1 A1	Possible ECF from **(iii)** **Allow** 1 mark for $v = 0.96$ m s^{-1}; used k for single spring

Question			Answer	Marks	Guidance
	(c)		force constant of spring arrangement) = $\frac{2k}{3}$ $\frac{2k}{3}x = ma$ $a = \frac{2}{3 \times 0.39}kx$ $a = 1.7\ kx$	M1 M1 A0	
			Total	**14**	

Question			Answer	Marks	Guidance
18	(a)		sum of clockwise moments (about a point / axis) = sum of anticlockwise moments (about the same point /axis)	B1	**Allow** total / Σ for 'sum'
	(b)		Allow the object to hang freely from one of the holes around the edge of the head gasket using a nail secured in a clamp stand. (AW) Draw a vertical line downwards using a plumb line. (AW) Repeat for at least one more hole. Where the lines intersect is the centre of gravity.	B1 B1 B1 B1	 **Allow** another correct method.
	(c)	(i)	(Sum of clockwise moments = sum of anticlockwise moments) $95 \times 9.81 \times 1.80$ / $120 \times 9.81 \times 1.00$ / $1.60 \times T\sin 30°$ $(95 \times 9.81 \times 1.80) + (120 \times 9.81 \times 1.00) = 1.60 \times T\sin 30°$ $T = 3.6 \times 10^3$ (N)	 C1 C1 A1	 **Note** answer to 3 s.f. is 3.57×10^3 (N)
		(ii)	$\sigma = \dfrac{3.6 \times 10^3}{\pi \times 0.015^2}$ $\sigma = 5.1 \times 10^3$ (kPa)	C1 A1	Possible ECF from part **(i)** **Allow** 1 mark for 5.1×10^6; POT error **Note** using 3.57×10^3 N gives 5.05×10^3 (kPa)
		(iii)	The clockwise moment decreases and therefore T decreases.	B1	**Allow** As the engine accelerates the tension in its supporting rope must be less than the weight of the engine and therefore T decreases.
			Total	**11**	

Question			Answer	Marks	Guidance
19	(a)		$mv - mu = F\Delta t$ (u = 0) / area under graph = Δp	C1	**Allow** 'impulse' for Δp
			$mv = \frac{0.010 + 0.040}{2} \times 150$	C1	**Allow** alternative methods for finding area.
			$mv = 3.75$ or $v = \frac{3.75}{0.16}$		
			$v = 23$ (m s^{-1})	A1	**Note** answer to 3 s.f. is 23.4 m s^{-1}
	(b)		Curve upwards with decreasing gradient.	M1	
			Curve starts at a non-zero velocity at t = 30 ms.	A1	
	(c)		$F\Delta t = mv - mu$		**Allow** other correct methods
			$T = \frac{0.16 \times 23}{0.80}$	C1	Possible ECF from **(a)**
			T = 4.6 (s)	A1	**Note** the answer is 4.7 (s) when 23.4 (m s^{-1}) is used
			Total	**7**	

Question			Answer	Marks	Guidance
20	(a)		The energy required per unit mass to change the temperature by 1 K / 1°C.	B1	**Allow**: $c = E/m\Delta\theta$, where E = energy, m = mass and $\Delta\theta$ = change in temperature.
	(b)	(i)	$E = m \times c \times \Delta\theta = 0.15 \times 4200 \times 55$ $E = 3.5 \times 10^4$ (J)	 A1	 **Note** answer to 3 s.f. is 3.47×10^4 (J)
		(ii)	(Energy transferred from water = energy transferred to glycerol) $0.150 \times 4200 \times (75 - \theta)$ or $0.020 \times 2400 \times (\theta - 20)$ $0.150 \times 4200 \times (75 - \theta) = 0.020 \times 2400 \times (\theta - 20)$ $\theta = 71$(°C)	 C1 C1 A1	
		(iii)	The temperature is less / different because of thermal energy of the water is also used to warm up the boiling tube. (AW)	B1	
	(c)		Graph showing constant temperatures during phase changes. Temperature increases linearly for the solid and the liquid. Steeper slope for the solid state.	B1 M1 A1	
			Total	**9**	

Question			Answer	Marks	Guidance
21	(a)		Force the mass to oscillate with a periodic force. (AW)	B1	
			The mass oscillates at maximum amplitude when the forcing frequency is equal to the natural frequency of the spring-mass system. (AW)	B1	
	(b)	(i)	$\omega = 2\pi \times 1.2$	C1	
			($a_{max} = \omega^2 A$); $a_{max} = [2\pi \times 1.2]^2 \times 3.0 \times 10^{-2}$	C1	
			maximum acceleration = 1.7 (m s^{-2})	A1	
		(ii)	Correct curve with peak of greater amplitude.	B1	
			Peak slightly right of first curve.	B1	**Allow** graph peaking at 1.2 (Hz)
	(c)	(i)	Using the graph to determine at least two ratios of the amplitudes.	M1	For example: 2.5/3.0 and 2.1/2.5
			Correct statement matching the ratios.	A1	For example: 'The statement is correct because 2.5/3.0 $\approx$ 2.1/2.5 $\approx$ constant.'
		(ii)	At time $t = 0$	M1	
			Oscillator has maximum speed and hence the greatest friction. (AW)	A1	
			Total	**11**	

Question			Answer	Marks	Guidance
22	(a)*		**Level 3 (5–6 marks)** Clear use of data and discussion of MBR. *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)** Some use of data and discussion of MBR. *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)** Limited use of data or limited discussion of MBR. *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× 6	**Indicative scientific points may include:** **Use of data** • The table of values for *d* and *v* support the idea of an expanding Universe. • Calculate of H_0 more than once using data. • age = $t = \frac{1}{H_0}$ used correctly to calculate *t*. • Age calculated correctly in s or in y. • Furthest galaxies travelling faster. • Space expanding in all directions. • Use data to plot graph of *v* against *d* to determine H_0 / graph of *d* against *v* to find *t*. • More data needed since anomalies in the table. **Discussion of MBR (microwave background radiation)** • Early Universe extremely hot / very dense. • High energy gamma photons existed in the early Universe. • As space expanded the wavelength of these photons / waves 'stretched' out. • We now observe this as microwave background radiation. • Temperature of the Universe is now 2.7 K
	(b)	(i)	$\Delta\lambda = \frac{\lambda v}{c} = \frac{486\times10^{-9}\times960\times10^{3}}{3.00\times10^{8}}$	C1	

Question			Answer	Marks	Guidance
			$\Delta\lambda$ = 1.56 (nm) $\lambda = 486 + 1.56 = 488$ (nm)	C1 A1	
		(ii)	d = 1.25 × 10^{-6} m $\theta = \sin^{-1}\left(\frac{2 \times 486 \times 10^{-9}}{1.25 \times 10^{-6}}\right)$ θ = 51°	C1 A1	**Allow** 1 mark $\theta = \sin^{-1}\left(\frac{2 \times 488 \times 10^{-9}}{1.25 \times 10^{-6}}\right)$ = 51°; incorrect 488 nm used instead of 486 nm.
	(c)		Dark matter / black holes	B1	**Allow**: anti-matter / dark energy
			Total	**12**	

Question			Answer	Marks	Guidance
23	(a)		$\lambda_{max} \times T$ should be constant if Wien's law is obeyed. At least data from three stars is used to carry out the test and a clear conclusion.	M1 A1	**Ignore** POT **Note** $\lambda_{max} \times T$ values are 2.91 ($\times 10^{-3}$), 2.91 ($\times 10^{-3}$), 2.88 ($\times 10^{-3}$) and 2.99 ($\times 10^{-3}$) – hence expect '*yes the law is obeyed*'.
	(b)	(i)	distance = $550 \times 9.5 \times 10^{15}$ (m) $L = \frac{4\pi\times(550\times9.5\times10^{15})^2}{4.0\times10^{-4}} \times 2.6 \times 10^{-11}$ $L = 2.2 \times 10^{31}$ (W)	C1 C1 A1	
		(ii)	($r = \sqrt{\frac{L}{4\pi\sigma T^4}}$) ; $r = \sqrt{\frac{2.2\times10^{31}}{4\pi\times5.67\times10^{-8}\times(3.1\times10^3)^4}}$ $r = 5.8 \times 10^{11}$ (m)	C1 A1	**Possible** ECF from **(i)** **Allow** any subject
		(iii)	mass = $4.4 \times 10^{-5} \times 4/3\pi \times (5.8 \times 10^{11})^3$ $g = \frac{6.67\times10^{-11}\times4.4\times10^{-5}\times{}^4/_3\pi\times(5.8\times10^{11})^3}{(5.8\times10^{11})^2}$ $g = 7.1 \times 10^{-3}$ (N kg^{-1})	C1 A1	**Possible** ECF from **(ii)**
			Total	**9**	