OCR
Oxford Cambridge and RSA

## …day June 20XX–Morning/Afternoon

**A Level Physics A**
**H556/01 Modelling physics**

**SAMPLE MARK SCHEME**

**Duration:** 2 hours 15 minutes

**MAXIMUM MARK 100**

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**This document consists of 20 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.

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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.

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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 **18a** and **23c**.

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 |

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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.

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**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.

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## SECTION A

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

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## SECTION B

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 16 | (a) | (i) | Circumference = (2 x 200) + (2π x 40) = 651.3 m<br><br>Time for A to complete one lap = $\frac{651.3}{20}$ = 33 (s) | C1<br><br>A1 | <br><br>accept 32.6 |
| | | (ii) | Distance moved by B = 23 x 32.6 = 749.8 m<br><br>(B has travelled 749.8m – 651.3m more than A) 98.5m to the right from its initial starting point.<br><br>Distance from A to B = (651.3/2) – 98.5 =227m | C1<br><br><br>A1 | Accept calculation of relative speed followed by relative distance.<br><br>Accept (651.3/2) – 108 using 33s to give 218m |
| | (b) | (i) | Constant acceleration from 0 shown correctly followed by constant velocity.<br><br>Constant velocity at 24 m $s^{-1}$ starting at t = 16 s | B1<br><br>B1 | |
| | | (ii) | <br><br>Distance moved by B = $(1/2x1.5x16^2) + 24(t – 16)$<br><br>$(1/2x1.5x16^2) + 24(t – 16) = 22t$<br><br>t = 96 (s) | <br><br>C1<br><br>C1<br><br>A1 | Alternative method of equating areas.<br><br>Distance moved by B = (8 x 24) + (24(t – 16))<br><br>22t = (8 x 24) + 24(t – 16)<br><br>t = 96 |
| | | | **Total** | **9** | |

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| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 17 | (a) | (i) | 250 x 60 = 15000 J<br><br>energy = $\frac{15000}{0.65}$ = 2.3 x $10^4$ (J) | C1<br><br>A1 | |
| | | (ii) | drag force = 0.4 x $6.0^2$ = 14.4 N<br><br>forward force = power/velocity = 250/6.0 = 41.7 N<br><br>acceleration = $\frac{41.7 - 14.4}{85}$ = 0.32 m $s^{-2}$ | C1<br><br>C1<br><br>A1 | |
| | (b) | (i) | weight; (tractive) force up slope; drag; (normal) reaction.<br><br>All forces in correct direction and correctly labelled. | B1 | |
| | | (ii) | 14.4 + (85 x 9.81 x sin $\theta$) = 41.7<br><br>$\theta$ = 1.9 ° | C1<br><br>A1 | **ecf** from **(a)(ii)** |
| | (c) | | any three from:<br>• drag reduces velocity **or** increases time to cross **or** some kinetic energy of cyclist goes to heat.<br>• longer crossing time results in cyclist at lower point on other side of gap.<br>• moment on bicycle<br>• rotation lowers height of front wheel.<br><br>Conclusion based on argument(s).<br>The maximum gap width is smaller. | B1 x 3<br><br>B1 | Allow argument based on:<br>• very short crossing time (< 0.43s at speed of 6$ms^{-1}$ up slope).<br>• energy changed to heat insignificant compared to KE<br>• amount of rotation very small in short time.<br><br>conclusion based on argument(s).<br>So no change in maximum gap width. |
| | | | **Total** | 12 | |

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| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 18 | (a)* | | **Level 3 (5–6 marks)**<br>All points E1, 2, 3 and 4 for equipment<br>All points M1, 2, 3 and 4 for measurements<br>For calculations expect C1, C2, C3 and C4<br>Expect at least two points from reliability<br><br>*There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.*<br><br>**Level 2 (3–4 marks)**<br>Expect E1 and E2; E3 or E4 for equipment<br>Expect M2 and two from M1, M3, M4 for measurements<br>For calculations expect at least C3 and C4<br>Expect at least one point from reliability<br><br>*There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.*<br><br>**Level 1 (1–2 marks)**<br>Expect at least E1 and E2 for equipment<br>Expect at least two from measurements<br>Expect C5 for the calculation<br>No real ideas for obtaining reliable results<br><br>*There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.*<br><br>**0 marks**<br>No response or no response worthy of credit. | **B1 x6** | The complete plan consists of four parts:<br><br>**Equipment used safety (E)**<br>1. Wire fixed at one end with load added to wire<br>2. Suitable scale with suitable marker on wire.<br>3. Micrometer screw-gauge **or** digital/vernier callipers for measuring diameter of wire.<br>4. Reference to safety concerning wire snapping<br><br>**Measurements (M)**<br>1. Original length from fixed end to marker on wire.<br>2. Diameter of wire.<br>3. Measure load.<br>4. New length of wire when load increased.<br><br>**Calculation of Young modulus. (C)**<br>1. Find extension (for each load) or strain (for each load)<br>2. Determine cross-sectional area or stress<br>3. Plot graph of load-extension **or** graph of stress-strain<br>4. Young modulus = gradient x original length/area **or** Young modulus = gradient<br>5. Calculate Young modulus from single set of measurements of load, extension, area and length.<br><br>**Reliability of results (R)**<br>1. Measure diameter in 3 or more places and take average.<br>2. Put on initial load to tension wire and take |

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| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| | | | | | up 'slack' before measuring original length.<br>3. Take measurements of extension while unloading to check elastic limit has not been exceeded.<br>4. Use long wire (to give measurable extension)<br>Scale or ruler parallel to wire. |
| | **(b)** | **(i)** | Elastic: material returns to original dimensions when load is removed.<br>Plastic: material has permanent change of shape when load is removed. | **B1** | |
| | | **(ii)** | The material is elastic because the removal of force returns the rubber to its original length.<br><br>The area under force-extension graph is work done.<br><br>Repeated stretching and releasing the rubber warms up the rubber because not all the strain energy is returned back. The area enclosed represents the amount of thermal energy.<br>During landing, some of the aeroplane's kinetic energy is transferred to thermal energy and therefore the aeroplane does not "bounce" during landing; hence this minimises the risk to passengers. | **B1**<br><br>**B1**<br><br>**B1** | <br><br><br><br>Mentioning 'hysteresis' is not enough to gain this mark. |
| | | | **Total** | **10** | |

SPECIMEN

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 19 | (a) | | Area under graph = 0.5 x 0.06 x 1.8 = 0.054 (Ns)<br>0.05 x v = 0.054, therefore v = 1.1 (m $s^{-1}$) | C1<br>A1 | |
| | (b) | (i) | Both forces shown in correct direction and arrows of same length. | B1 | |
| | | (ii) | Zero. | B1 | |
| | | (iii) | (Conservation of momentum) $u_X = v_X + v_Z$<br>(Conservation of kinetic energy) $u^2_X = v^2_X + v^2_Z$<br>Shows $v_x = 0$ by substitution<br>$v_Z = u_X$ by substitution of $v_x = 0$ | C1<br>C1<br>C1<br>A1 | |
| | | | **Total** | 8 | |

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| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 20 | (a) | | Ensure largest possible proportion of flask is immersed.<br><br>Make volume of tubing small compared to volume of flask.<br><br>Remove heat source and stir water to ensure water at uniform temperature throughout.<br><br>Allow time for heat energy to conduct through glass to air before reading temperature. | B1 x 4 | |
| | (b) | (i) | Pressure is caused by collisions of particles with sides.<br><br>Velocity of particles (and volume of gas) are not zero at 0°C | B1<br><br>B1 | |
| | | (ii) | **1:**<br>Gradient of graph $0.75 \times 10^2 / 100 = 0.75$<br><br>Number of moles of gas = gradient/R = 0.75/8.31 = 0.09<br><br>Mass of gas = $0.09 \times 6.02 \times 10^{23} \times 4.7 \times 10^{-27} = 2.5 \times 10^{-4}$ (kg)<br>**2:**<br>Internal energy = 3/2 x NkT<br><br>= $1.5 \times 0.09 \times 6.02 \times 10^{23} \times 1.38 \times 10^{-23} \times (100 + 273)$<br><br>= 410 (J) | C1<br><br>A1<br><br>C1<br><br>A1 | Alternative method<br>Internal energy = 3/2 x p x V<br><br>At $\theta$ = 100°C pV = $2.73 \times 10^2$<br><br>Internal energy = $1.5 \times 2.73 \times 10^2 = 410$ (J) |
| | | | **Total** | **10** | |

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| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 21 | (a) | | Resultant force from springs is proportional to displacement from centre **or** acceleration (of mass) is proportional to displacement from centre.<br><br>Directed to centre or fixed point. | **B1**<br><br>**B1** | |
| | (b) | (i) | Period from graph = 500/3.5 = 143 ms<br><br>Acceleration = $\omega^2$ A = $(2\pi/0.143)^2$ x 0.006 = 12 (m $s^{-2}$) | **C1**<br><br>**A1** | |
| | | (ii) | KE = 0.5 x 0.005 x $(2\pi$ / 0.143 x 0.006$)^2$<br><br>KE = 1.7 x $10^{-4}$ (J) | **C1**<br><br>**A1** | |
| | (c) | | Graph correct shape and always positive and suitable scale on kinetic energy axis.<br><br>Maxima occur at zero displacement times. | **B1**<br><br>**B1** | |

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| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| | (d) | | **Accept any sensible and successful method.**<br>**Stroboscope:** Any two from<br>• Use of stroboscope of known frequency or period<br>• Photograph to capture several positions on one picture<br>• Measure displacement from centre using a scale put behind the mass.<br>**or**<br>**Motion sensor:** Any two from<br>• Motion sensor connected to data logger which sends information on displacement and time to computer.<br>• Sensor placed close to moving mass to eliminate reflections from other objects.<br>• Small reflector attached to mass.<br><br>**Safeguards to ensure accuracy**<br>**Stroboscope:** Any two from<br>• Use frequency such that positions of mass are close together on photograph.<br>• distance scale close to oscillating mass or camera set back from mass to reduce parallax.<br>• Camera should be directed at equilibrium point or at 90° to oscillation.<br>**or**<br>**Motion sensor:** Any two from<br>• Any attached reflector should not cause damping.<br>• Motion sensor directed along line of oscillation or motion sensor signal blocked by supports so must be as near to line of oscillation as possible.<br>• Use thin supports to reduce reflections. | **B1 x 2**<br><br>**B1 x 2** | Video camera with freeze frame facility, where time between frames is known. Apply marking points as for the stroboscope. |
| | | | **Total** | **12** | |

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| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 22 | (a) | | Force is proportional to the product of the mass of each asteroid. **and** the force is inversely proportional to the distance squared between the centres of mass of the asteroids. | B1 | |
| | (b) | (i) | Any sensible suggestion, e.g. Satellites used for global communication, instant access to news, weather forecasting etc. | B1 | |
| | | (ii) | $g = (6400/15300)^2 \times 9.81$<br><br>$g = 1.72$ (N kg$^{-1}$) | C1<br><br>A1 | |
| | | (iii) | Acceleration towards centre = 1.72 m s$^{-2}$ or centripetal force = mass of satellite x 1.72 N<br><br>$T^2 = 4 \times \pi^2 \times 1.53 \times 10^7 / 1.72$<br><br>$T = 1.87 \times 10^4$ (s) | C1<br><br>C1<br><br>A1 | ecf (b)(i)<br><br><br><br>Allow 1.9 |
| | (c) | | Use of $M = gr^2 / G$ (accept any subject)<br><br>Density = $3g / 4\pi rG = 3 \times 9.81/4\pi \times 6.4 \times 10^6 \times 6.67 \times 10^{-11}$<br><br>$= 5.49 \times 10^3$ (kg m$^{-3}$) | C1<br><br>C1<br><br>A1 | Calculation using g = 1.72 at radius of 15300 km<br>Possible ecf from **(b)(i)**<br><br>Density = $\frac{3 \times 1.72 \times (1.53 \times 10^7)^2}{4\pi \times (6.4 \times 10^6)^3 \times 6.67 \times 10^{-11}}$<br><br>$= 5.50 \times 10^3$ kg m$^{-3}$ |
| | | | **Total** | 10 | |

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| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 23 | (a) | | Apparent motion or displacement of a star relative to the position of more distant stars.<br><br>Caused by the Earth's orbit around the Sun.<br><br>An angle of parallax of 1 arcsecond when displacement of Earth is 1AU corresponds to distance 1 pc | B1<br><br>B1<br><br>B1 | |
| | (b) | (i) | $v = \frac{(489.8 - 486.1) \times 3 \times 10^8}{486.1}$ (= $2.28 \times 10^6$ m $s^{-1}$)<br><br>age = $1/H_o = \frac{16.5 \times 10^6 \times 3.1 \times 10^{16}}{2.28 \times 10^6}$<br><br>age = $2.2 \times 10^{17}$ (s) | C1<br><br>C1<br><br>A1 | |
| | | (ii) | Hydrogen is most common element in stars or Hydrogen has most intense (spectral) lines.<br><br>Intensity of light from other elements may be too low for accurate measurement. | B1<br><br>B1 | |

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| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 23 | (c)* | | **Level 3 (5–6 marks)**<br>Expect T1 and T2 for the Big Bang Theory<br>Expect full discussion of red shift points R1, 2, 3 and 4<br>Expect at least B1 and B2 for the Blue Shift<br>Expect C1 and any three from C2, C3, C4, C5 for CMBR<br><br>*There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.*<br><br>**Level 2 (3–4 marks)**<br>Expect T1 and T2 for the Big Bang Theory<br>Expect R1 and R2; red shift identified but no explanation why it implies an expanding Universe<br>Expect B1 and B2; blue shift identified with no explanation of cause<br>Expect any three from C1, 2, 3, 4 and 5; CMBR evidence recalled but linked to the Big Bang<br><br>*There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* | **B1x6** | **Big Bang Theory (T)**<br>1. Predicts that all galaxies will be receding.<br>2. Galaxy velocity proportional to distance from Earth.<br><br>**Red Shift (R)**<br>1. Radiation from Virgo shows increase in wavelength or red shift<br>2. Change in wavelength caused by motion of galaxy or reference to Doppler Effect<br>3. Evidence that Virgo is receding from Earth.<br>4. Support for Big Bang theory.<br><br>**Blue Shift (B)**<br>1. Andromeda shows blue shift<br>2. Andromeda approaching Earth<br>3. Caused by gravitational attraction.<br><br>**CMBR (C)**<br>1. Formed as gamma radiation at Big Bang<br>2. Galactic red shift to microwave wavelength<br>3. Intensity is uniform in all directions<br>4. Corresponds to a temperature of 2.7K<br>5. (Very small) ripples in intensity corresponding to formation of first stars or galaxies. |

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| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| | | | **Level 1 (1–2 marks)**<br>Expect T1 or T2 for the Big Bang Theory<br>Expect R1, R2 or B1, B2; red shift or blue shift identified but without explanation or link to Big Bang Theory<br>Expect at least one from C1, 2, 3, 4 and 5; CMBR evidence recalled but not linked to the Big Bang<br><br>*There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.*<br><br>**0 marks**<br>No response or no response worthy of credit. | | |
| | | | **Total** | **14** | |

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# Summary of updates

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

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