

YEAR 2 | MODULE 5 | PACK 03

Orbital, magnetic and Doppler applications

Official past-paper questions

2017-2023 | OCR A H556 | 5.2 applied with later sections of modules 5 and 6

32 marks | 10 question entries

Later applications - use after the required topics

Use: attempt the session after learning its content. Try without notes; record any help used. Mark the session, identify the reason for lost marks, then revisit those questions after a few days.

Format: all MCQs appear first with their complete answer boxes. Written extracts retain the original paper's answer space. Only the subparts named in the source reference are assigned.

Do later: these questions apply circular motion alongside gravitation, geostationary orbits, magnetic force or the Doppler effect. Each question identifies its prerequisites. Complete the relevant questions as those topics are taught; this pack is separate from the core chapter test.

Reserved: all 2024 and 2025 papers are excluded. These files contain official examination questions only; no sample, specimen or practice papers.

Name: _____

First attempt: _____ Score: _____ / 32

[Official data, formulae and relationships booklet](#)

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CM identifiers are stable across the question packs and mark schemes; Q numbers refer to this pack. All MCQs appear first.

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Q01 | CM04

1 mark

June 2023 | H556/01 | Q11

- 11 A satellite is in geostationary orbit 36 000 km above the Earth's surface. The Earth has a radius of 6400 km.

At what speed is the satellite moving relative to the centre of the Earth?

- A 0 ms^{-1}
- B 490 ms^{-1}
- C 2.6 kms^{-1}
- D 3.1 kms^{-1}

Your answer

[1]

Q02 | CM01

1 mark

June 2017 | H556/02 | Q11

- 11 An electron moves in a circle of radius 2.0 cm in a uniform magnetic field of flux density 170 mT.

What is the momentum of this electron?

- A $3.4 \times 10^{-3} \text{ kg ms}^{-1}$
- B $5.4 \times 10^{-17} \text{ kg ms}^{-1}$
- C $1.4 \times 10^{-18} \text{ kg ms}^{-1}$
- D $5.4 \times 10^{-22} \text{ kg ms}^{-1}$

Your answer

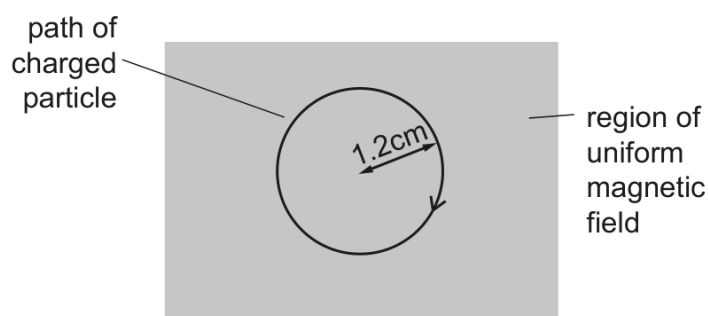
[1]

Q03 | CM02

1 mark

June 2018 | H556/02 | Q10

- 10 A charged particle moves in a circular path of radius 1.2 cm in a uniform magnetic field.



The direction of the magnetic field is perpendicular to the plane of the paper.

The particle has mass m , charge $+Q$ and speed v .

Another particle of mass $3m$, charge $+2Q$ and speed v moves in a circular path of radius R in the same magnetic field.

What is the value of R ?

- A 0.8 cm
- B 1.2 cm
- C 1.8 cm
- D 7.2 cm

Your answer

[1]

Q04 | CM03

1 mark

June 2022 | H556/02 | Q7

- 7 A particle is moving at right angles to a uniform magnetic field of flux density B . The particle has mass m , charge q and moves in a circular arc of radius r in the region of the magnetic field.

What quantities are required to determine the momentum of this particle?

- A B , q and r
- B B , q and m
- C B , q , r and m
- D q , r and m

Your answer

[1]

Q05 | CM09A3

3 marks

June 2018 | H556/01 | Q17(a)(iii)

Requires: Newton's law of gravitation.

17 (a) Phobos is one of the two moons orbiting Mars. Fig. 17.1 shows Phobos and Mars.

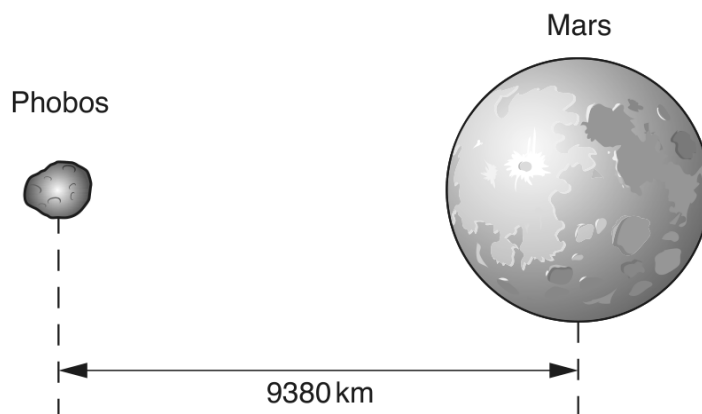


Fig. 17.1

The orbit of Phobos may be assumed to be a circle. The centre of Phobos is at a distance 9380 km from the centre of Mars and it has an orbital speed $2.14 \times 10^3 \text{ m s}^{-1}$.

(iii) Calculate the mass M of Mars.

$M = \dots\dots\dots \text{ kg [3]}$

Only (a)(iii) is assigned. The original orbital speed and radius are retained, so no numerical answer to (a)(ii) is needed. Requires gravitation.

Q06 | CM22

3 marks

June 2022 | H556/01 | Q23(a)

Requires: Newton's law of gravitation.

23 (a) A planet of mass m is in a circular orbit around a star of mass M .

Use the equation for Newton's law of gravitation and your knowledge of circular motion to show that the relationship between the orbital period T of the planet and its orbital radius r is $T^2 \propto r^3$.

[3]

Only (a) is assigned; the elliptical-orbit questions are omitted. Requires gravitation.

Q07 | CM18

6 marks

November 2021 | H556/01 | Q20(b)

Requires: Gravitational potential energy and geostationary orbits.

- (b)* A satellite is in a circular geostationary orbit around the centre of the Earth. The satellite has both kinetic energy and gravitational potential energy.

The mass of the satellite is 2500 kg and the radius of its circular orbit is 4.22×10^7 m.
The mass of the Earth is 5.97×10^{24} kg.

- Describe some of the features of a geostationary orbit.
- Calculate the **total** energy of the satellite in its geostationary orbit.

[6]

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Only (b) is assigned. All masses, orbital radius and original response space are retained. Requires gravitational potential energy and geostationary-orbit features.

Q07 | CM18 - continued

6 marks

November 2021 | H556/01 | Q20(b)

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Additional answer space if required.

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Only (b) is assigned. All masses, orbital radius and original response space are retained. Requires gravitational potential energy and geostationary-orbit features.

Q08 | CM13

3 marks

June 2019 | H556/02 | Q20(a)

Requires: Magnetic force on a moving charge.

20 Fig. 20 illustrates a device used to determine the relative abundance of charged rubidium ions.

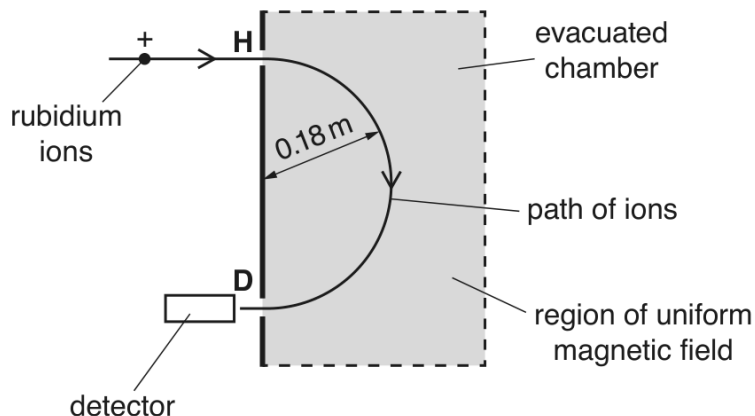


Fig. 20

A uniform magnetic field is applied to an evacuated chamber. The direction of the magnetic field is perpendicular to the plane of the paper.

A beam of positive rubidium ions enters the chamber through a hole at **H**. The ions travel in a semi-circular path in the magnetic field. The ions are detected at point **D**.

- (a) Each rubidium ion has charge $+1.6 \times 10^{-19} \text{ C}$ and speed $4.8 \times 10^4 \text{ ms}^{-1}$.
 The radius of the semi-circular path of the ions is 0.18 m.
 The mass of a rubidium ion is $1.4 \times 10^{-25} \text{ kg}$.

Calculate the magnitude of the magnetic flux density B of the magnetic field.

$B = \dots\dots\dots \text{ T [3]}$

Only (a) is assigned. The original charge, mass, speed and radius are retained; radioactive-decay questions are omitted. Requires magnetic force.

Q09 | CM15

3 marks

June 2019 | H556/03 | Q6(c)(i), (c)(iv)

Requires: Doppler effect for (c)(iv).

- (c) In cosmology, the Doppler effect can be observed with light from distant galaxies. The Doppler effect can also be observed with sound waves.

Two students use sound waves to investigate the Doppler effect.

In an open space, one student swings a loudspeaker at constant speed in a horizontal circle of radius 0.60 m.

The other student stands a large distance away and holds a microphone. The microphone is connected to a data logger and computer.

Fig. 6.1 shows the situation, viewed from above.

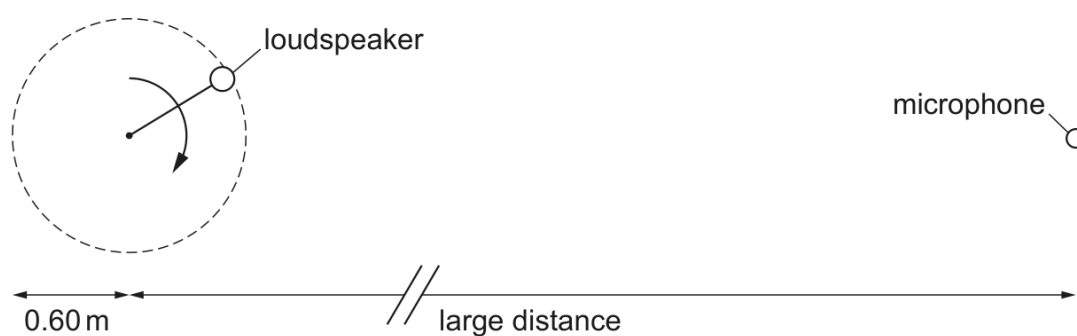


Fig. 6.1

The loudspeaker emits sound in all directions at a single frequency $f_0 = 1700\text{ Hz}$.

Fig. 6.2 shows the variation with time t of the frequency f received by the microphone.

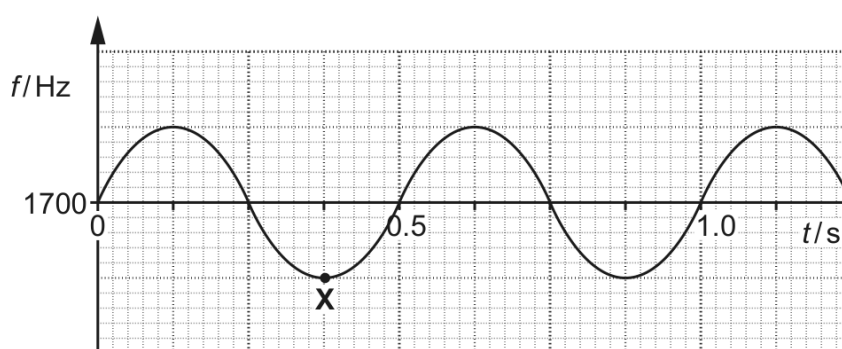


Fig. 6.2

Only (c)(i) and (c)(iv) are assigned. Both original figures are retained. Part (c)(iv) needs Doppler-effect knowledge; its position question does not need the omitted numerical frequency-shift or y-axis-scale answers.

Q09 | CM15 - continued

3 marks

June 2019 | H556/03 | Q6(c)(i), (c)(iv)

- (i) Use Fig. 6.2 to show that the speed of the loudspeaker is 7.5 m s^{-1} .

[2]

- (iv) Mark with an **X** on Fig. 6.1 the position of the loudspeaker which corresponds to the point **X** on Fig. 6.2.

[1]

Only (c)(i) and (c)(iv) are assigned. Both original figures are retained. Part (c)(iv) needs Doppler-effect knowledge; its position question does not need the omitted numerical frequency-shift or y-axis-scale answers.

Q10 | CM12

10 marks

June 2018 | H556/03 | Q3

Requires: Gravitation and Doppler shift.

- 3 A binary star is a pair of stars which move in circular orbits around their common centre of mass.

In this question consider the stars to be point masses situated at their centres.

- (a) Fig. 3.1 shows a binary star where the mass of each star is m . The stars move in the same circular orbit.

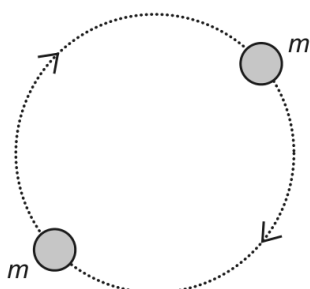


Fig. 3.1

- (i) Explain why the stars of equal mass must always be diametrically opposite as they travel in the circular orbit.

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 [2]

- (ii) The centres of the two stars are separated by a distance of $2R$ equal to $3.6 \times 10^{10} \text{ m}$, where R is the radius of the orbit. The stars have an orbital period T of 20.5 days. The mass of each star is given by the equation

$$m = \frac{16\pi^2 R^3}{GT^2}$$

where G is the gravitational constant.

Calculate the mass m of each star in terms of the mass $M_{\odot}$ of the Sun.

$$1 \text{ day} = 86400 \text{ s}$$

$$M_{\odot} = 2.0 \times 10^{30} \text{ kg}$$

$$m = \dots\dots\dots M_{\odot} \text{ [3]}$$

The complete question is assigned. Its original orbital-mass equation, data and diagrams are retained. Requires gravitation and Doppler shift.

Q10 | CM12 - continued

10 marks

June 2018 | H556/03 | Q3

- (iii) The stars are viewed from Earth in the plane of rotation. The stars are observed using light that has wavelength of 656 nm in the laboratory. The observed light from the stars is Doppler shifted.

Calculate the maximum change in the observed wavelength $\Delta\lambda$ of this light from the orbiting stars. Give your answer in nm.

$\Delta\lambda = \dots\dots\dots$ nm [2]

- (b) Fig. 3.2 shows a binary star where the masses of the stars are $4m$ and m .

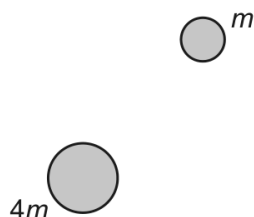


Fig. 3.2

- (i) The centre of mass of the binary star lies at the surface of the star of mass $4m$. Draw on Fig. 3.2 two circles to represent the orbits of **both** stars. [1]
- (ii) Explain why the smaller mass star travels faster in its orbit than the larger mass star.

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The complete question is assigned. Its original orbital-mass equation, data and diagrams are retained. Requires gravitation and Doppler shift.