



**Physics**

International Baccalaureate Diploma Programme

**2023 specification**  
first assessment in 2025

# Topic Tests for IB Physics

## D. Fields

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# Teacher's Introduction

These topic tests have been designed to help you and your students assess their knowledge of a topic after you have taught each part of **Theme D – Fields (Topics D.1–D.4)** for the **IB Physics Diploma Programme (standard level and higher level)**.

This part of the course includes the following topics:

1. Gravitational fields
2. Electric and magnetic fields
3. Motion in electromagnetic fields
4. Induction

Each topic test closely follows the content of the specification and includes:

- **Multiple-choice questions:** These are not in exam style, and the purpose of these is to test different elements, knowledge and skills from the specification in a variety of styles. Question types include general recall, explanation of key concepts, and application questions.
- **Structured-answer questions:** Where appropriate, topics may contain one or more extended-response questions to prepare students for what they might meet in the exam, and to test exam skills. Question types include long-form explanations, match-ups, copy and complete, and fact recall.

Mathematical skills are also covered in these topic tests.

The table below shows the content, specification reference and number of marks allocated to each test. Tests have been provided in both write-on and non-write-on formats.

Topic	Section	Marks per section (SL)	Marks per section (HL)
D.1 Gravitational fields	Multiple-choice questions	6	8
	Structured-answer questions	38	58
	<b>Total</b>	<b>44</b>	<b>66</b>
D.2 Electric and magnetic fields	Multiple-choice questions	6	7
	Structured-answer questions	35	61
	<b>Total</b>	<b>41</b>	<b>68</b>
D.3 Motion in electromagnetic fields	Multiple-choice questions	6	
	Structured-answer questions	41	
	<b>Total</b>	<b>47</b>	
D.4 Induction	Multiple-choice questions	6	
	Structured-answer questions	33	
	<b>Total</b>	<b>39</b>	

Tests have been designed to take approximately 30–40 minutes to complete. Students are able to see the number of marks awarded for each question, allowing them to gauge the level of detail they will require for the answers. Full answers with marks are included at the end of each test. Additionally, it makes the resource a suitable tool for students to use independently.

The topic tests are suitable for a classroom assessment, revision aid or homework task and are, therefore, suitable for use immediately after a topic is completed in class or at the end of teaching the course.

It is recommended that students have access to a calculator to complete the questions.

We hope you find these tests useful during your teaching.

May 2025

## D.1 Gravitational fields

### Multiple-choice questions

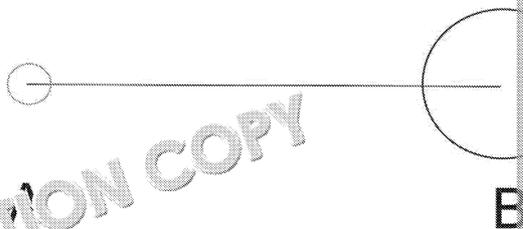
1. The field strength on the surface of a spherical planet of density  $\rho$  kg m<sup>-3</sup> and radius  $r$  is  $g$ . What is the field strength on the surface of a planet of density  $3\rho$  and radius  $2r$ ?
 

A. $1.5g$ <input type="checkbox"/>	C. $0.5g$ <input type="checkbox"/>
B. $3g$ <input type="checkbox"/>	D. $0.17g$ <input type="checkbox"/>
  
2. Under what circumstances can an extended body be treated as a point mass?
  - i. When the gravitational field can be considered uniform
  - ii. When the centre of mass and the centre of gravity coincide
  - iii. When the dimensions of the body are negligible in comparison to the distance to the source of the gravitational field it sits in
  - iv. When the body is spherical

A. i only <input type="checkbox"/>	C. i, ii and iii only <input type="checkbox"/>
B. ii only <input type="checkbox"/>	D. i, iii and iv only <input type="checkbox"/>
  
3. The units of the gravitational constant can be written as:
 

A. $\text{m}^3\text{s}^{-2}\text{kg}^{-1}$ <input type="checkbox"/>	C. $\text{m}^3\text{s}^{-2}\text{kg}^3$ <input type="checkbox"/>
B. $\text{m}^2\text{s}^{-2}\text{kg}^{-3}$ <input type="checkbox"/>	D. $\text{ms}^{-1}\text{kg}^{-1}$ <input type="checkbox"/>
  
4. Gravitational fields are:
  - i. never truly uniform
  - ii. always attractive
  - iii. represented by field lines that can never cross
  - iv. represented by field lines, the distance between which indicates the strength of the field

A. i only <input type="checkbox"/>	C. i, ii and iii only <input type="checkbox"/>
B. ii only <input type="checkbox"/>	D. i, ii, iii and iv only <input type="checkbox"/>
  
5. Planet A has radius  $R$ , average density  $\rho$  kg m<sup>-3</sup>. Planet B has radius  $4R$ , average density  $\rho$  kg m<sup>-3</sup>. At what distance from planet A, along a line joining their centres of gravity, will the gravitational field be zero?



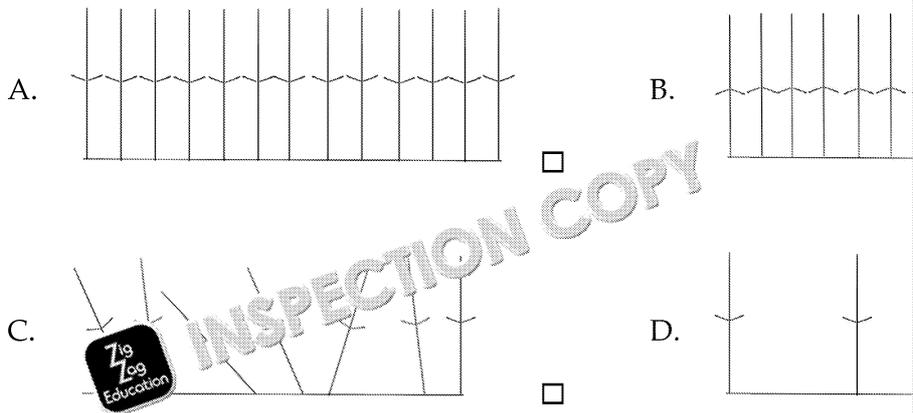
- |   |  |
|---|--|
| A. $1/4$ of the distance between them <input type="checkbox"/>  |  |
| B. $1/3$ of the distance between them <input type="checkbox"/>  |  |
| C. $1/4$ of the distance between them <input type="checkbox"/>  |  |
| D. $1/34$ of the distance between them <input type="checkbox"/> |  |

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6. Which of these diagrams represents the strongest uniform gravitational field?



**HT additional questions**

7. The gravitational field strength at a point in the field around an object is given by a graph of potential against distance from the object using:
- A. The area under the graph
  - B. The value of the potential divided by the value of the distance at that point
  - C. The value of the potential at the point multiplied by the mass of the object
  - D. The gradient of the tangent to the graph at the point
8. The effect of the atmosphere on an object orbiting Earth is:
- A. None – the upthrust is balanced by the viscous drag
  - B. The height of orbit is unaffected but the speed is reduced
  - C. The height of orbit and the speed of orbit are reduced
  - D. The height of orbit is reduced but the speed is increased due to conservation of angular momentum

**Structured-answer section**

1. (a) State Kepler's laws.

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- (b) Use Newton's universal law of gravitation to show that Kepler's 3<sup>rd</sup> law holds for an object mass  $m$  in a circular orbit of radius  $R$  around a planet



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- (c) Sketch graphs to show the variation of gravitational field strength
- (i) around a spherical mass  $M$  kg, radius  $R$  m
  - (ii) around a spherical mass  $2M$  kg, radius  $2R$  m



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- (d) How far from  $M$  is the point where the net gravitational field is zero?



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2. (a) Explain where and why we consider the gravitational field around

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(b) If the gravitational field strength at the surface of Earth is measured with precision, it is found to vary. State and explain why this might be

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(c) Show that the units  $\text{ms}^{-2}$  and  $\text{Nkg}^{-1}$  are the same.

3. Calculate the average density of Earth using the following data:

- $g$  on surface of Earth =  $9.81 \text{ ms}^{-2}$
- average radius of Earth =  $6370 \text{ km}$



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**HT additional questions**

4. (a) Derive an expression for the orbital speed of an object mass  $m$  kg of mass  $M$  kg in a circle of radius  $r$  m

(b) Derive an expression for the escape speed of a mass  $m$  kg at a distance  $r$  m from the centre of mass of mass  $M$  kg

5. (a) Define gravitational potential at a point in a gravitational field.

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(b) A student says: 'The gravitational potential at a distance  $R$  m from a planet of mass  $M$  kg is  $V$  Jkg<sup>-1</sup>'.  
What is wrong with this statement? Explain your answer.

.....  
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(c) How far from the same planet will the magnitude of the gravitational field be 1 % of  $V$ ?

.....

(d) How much work must be done to remove an object of mass 120 kg from the surface of Earth so that it never returns?  $V$  at surface of Earth = -63 MJkg<sup>-1</sup>



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6. (a) Define gravitational potential energy for a system, in terms of work done.

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(b) State an expression for the gravitational potential energy,  $E_p$ , for two masses,  $m_1$  and  $m_2$ , where their centres of mass are  $r$  metres apart.

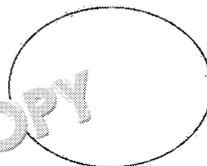
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(c) (i) What is an equipotential surface?



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(ii) Add three equipotentials to the diagram below showing equal potential between them.



(d) State the relationship between the gravitational field lines in a region and the equipotentials in the same region.

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## D.1 Gravitational fields

### Multiple-choice questions

- The field strength on the surface of a spherical planet of density  $\rho$  kg m<sup>-3</sup> and radius  $r$  is  $g$ . What is the field strength on the surface of a planet of density  $3\rho$  and radius  $2r$ ?
  - 1.5 g
  - 3 g
  - 0.5 g
  - 0.17 g
- Under which circumstances can an extended body be treated as a point mass in a gravitational field?
  - When the gravitational field can be considered uniform
  - When the centre of mass and the centre of gravity coincide
  - When the dimensions of the body are negligible in comparison to the distance to the source of the gravitational field it sits in
  - When the body is spherical

Answer	
A.	i only
B.	ii only
C.	i, ii and iii only
D.	ii, iii and iv only

- The units of the gravitational constant  $G$  can be written as:
  - $\text{m}^3\text{s}^{-2}\text{kg}^{-1}$
  - $\text{m}^2\text{s}^{-2}\text{kg}^{-3}$
  - $\text{m}^3\text{s}^{-2}\text{kg}^{-1}$
  - $\text{ms}^{-2}\text{kg}^{-1}$
- Gravitational fields are:
  - never truly uniform
  - always attractive
  - represented by field lines that can never cross
  - represented by field lines, the distance between which indicates the strength of the field

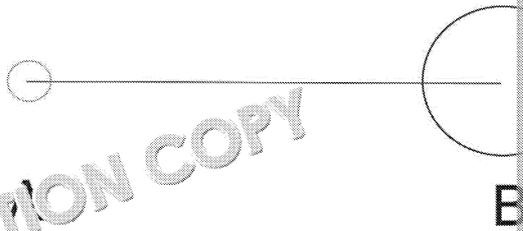
Answer	
A.	i only
B.	ii only
C.	i, ii and iii only
D.	i, ii, iii and iv

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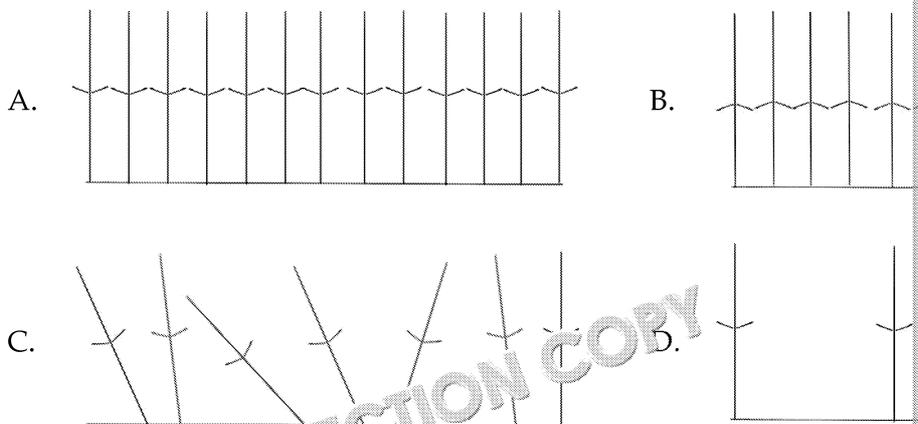
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5. Planet A has radius  $R$ , average density  $\rho \text{ kg m}^{-3}$ . Planet B has radius  $4R$  and average density  $\rho \text{ kg m}^{-3}$ . At what distance from planet A, along a line joining their centres of gravity, will the gravitational field be zero?



- A.  $1/4$  of the distance between them  
 B.  $1/3$  of the distance between them  
 C.  $1/16$  of the distance between them  
 D.  $1/34$  of the distance between them
6. Which of these diagrams represents the strongest uniform gravitational field?



### HT additional questions

7. The gravitational field strength at a point in the field around an object can be determined from a graph of potential against distance from the object using:
- A. The area under the graph  
 B. The value of the potential divided by the value of the distance at that point  
 C. The value of the potential at the point multiplied by the mass of the object  
 D. The gradient of the tangent to the graph at the point
8. The effect of the atmosphere on an object orbiting Earth is:
- A. None – the upthrust is balanced by the viscous drag  
 B. The height of orbit is unaffected but the speed is reduced  
 C. The height and the speed of orbit are reduced  
 D. The height of orbit is reduced but the speed is increased due to conservation of angular momentum

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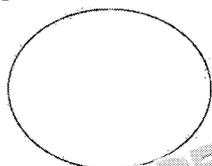


## Structured-answer section

- State Kepler's laws.
  - Use Newton's universal law of gravitation to show that Kepler's Law of Periods holds for an object mass  $m$  in a circular orbit of radius  $R$  around a planet of mass  $M$ .
  - Sketch graphs to show the variation of gravitational field strength  $g$  with distance  $r$  from the centre of mass of the planet.
    - around a spherical mass  $M$  kg, radius  $R$  m
    - around a spherical mass  $2M$  kg, radius  $2R$  m
  - How far from  $M$  is the point where the net gravitational field is zero?
- Explain why we consider the gravitational field around Earth to be uniform.
  - If the gravitational field strength at the surface of Earth is measured with great precision, it is found to vary. State and explain why this might be the case.
  - Show that the units  $\text{ms}^{-2}$  and  $\text{Nkg}^{-1}$  are the same.
- Calculate the average density of Earth using the following data:
  - $g$  on surface of Earth =  $9.81 \text{ ms}^{-2}$
  - average radius of Earth =  $6370 \text{ km}$

## HT additional questions

- Derive an expression for the orbital speed of an object mass  $m$  kg in a circular orbit of radius  $r$  m around a planet of mass  $M$  kg.
  - Derive an expression for the escape speed of a mass  $m$  kg at a distance  $r$  m from the centre of mass of mass  $M$  kg.
- Define gravitational potential at a point in a gravitational field.
  - A student wrote 'The gravitational potential at a distance  $R$  m from a planet of mass  $M$  kg is  $VJ$ '.  
What is wrong with this statement? Explain your answer.
  - How much work must be done to move an object of mass  $m$  kg from the same planet will the magnitude of the gravitational field strength be  $1/4$  of  $V$ ?
  - How much work must be done to remove an object of mass  $120 \text{ kg}$  from the surface of Earth so that it does not return?  $V$  at surface of Earth =  $-63 \text{ MJkg}^{-1}$ .
- Define gravitational potential energy for a system, in terms of work done.
  - State an expression for the gravitational potential energy,  $E_p$ , for two masses  $m_1$  and  $m_2$  where their centres of mass are  $r$  metres apart.
  - What is an equipotential surface?
    - Copy the diagram below and add three equipotentials showing the relationship between the gravitational field lines and the equipotentials in the same region.



- State the relationship between the gravitational field lines in a region and the equipotentials in the same region.

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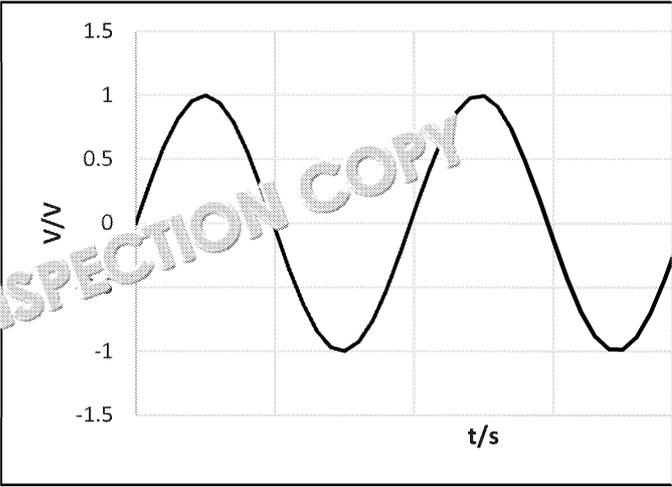
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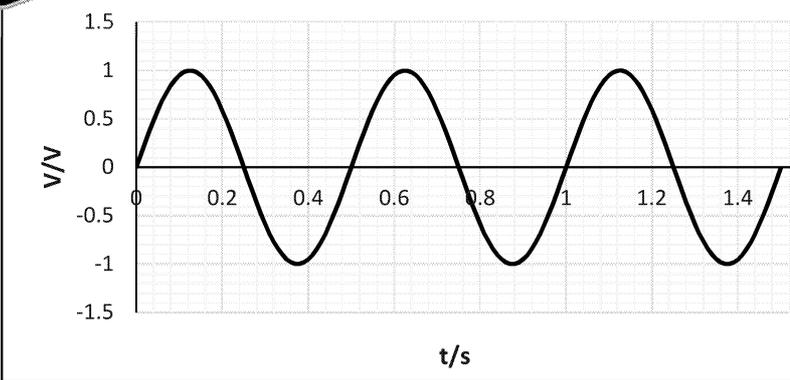
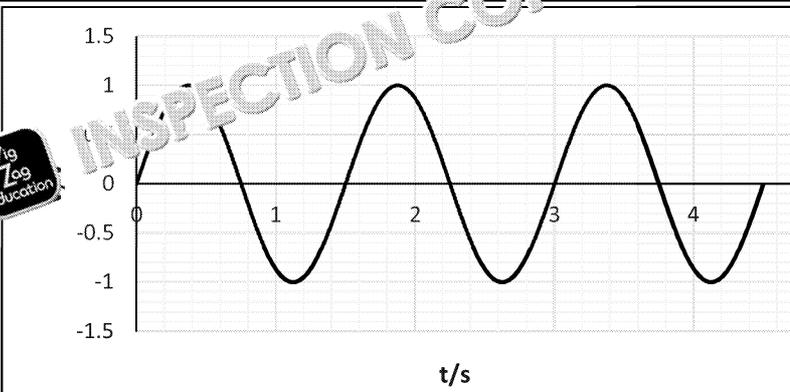
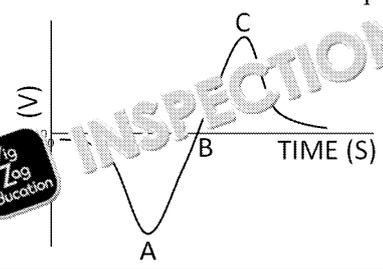
## D.4 Induction

Question	Answer
<b>Multiple-choice questions</b>	
1	A – 0.020 Wb $\Phi = BA \cos \theta = 0.55 \times 0.20^2 \times \cos(25) = 0.020 \text{ Wb}$
2	C – 1.7 mV After 10 seconds, the velocity will be $v = 9.81 \times 10 = 98.1 \text{ ms}^{-2}$ $\epsilon = Blv$ $\epsilon = 6.9 \times 10^{-5} \times 0.25 \times 98.1$ $\epsilon = 1.7 \text{ mV}$
3	C – The conversion of energy
4	$\epsilon = -N \frac{d\phi}{dt}$ $\phi = BA$ $\frac{d}{dt} \phi = \frac{\Delta BA}{t}$ $\frac{d}{dt} \phi = \frac{-4 \times 10^{-5} \times 0.50^2}{3 \times 10^{-3}}$ $\epsilon = -\frac{d}{dt} \phi \times N$ $\epsilon = -3.3 \times 10^{-4} \times 2000$ $\epsilon = -0.67 \text{ V}$
5	B – 
6	C – $4\epsilon \text{ V}$ and $2f \text{ Hz}$
<b>Structured-answer section</b>	
1 (a)	Magnetic fields affect moving charge (1) There is a force on (each of) the free electrons (1) The direction of the force can be established using Fleming's left-hand rule (1) The free electrons are 'pushed' to one end of the conductor (1) Creating a charge imbalance between the ends of the conductor (1) And so a difference of potential between the ends (1)
1 (b) (i)	Connecting the ends of the conductor to a complete circuit (1)
1 (b) (ii)	Lenz's law states that the induced emf will be in such a direction as to oppose the change that is causing it (1) The current will flow to create a current, which (by Fleming's left-hand rule) produces a force in the opposite direction to the motion of the conductor (1)
1 (c)	Faraday's law of electromagnetic induction states that the induced emf is proportional to the rate of change of flux linkage with the conductor (1) The emf can be increased by: <ul style="list-style-type: none"> <li>• Moving the conductor closer to a right angle with the field (1)</li> <li>• Increasing the speed of the conductor through the field (1)</li> <li>• Increasing the flux density of the field (1)</li> </ul>

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Question	Answer
2 (a)	$\varepsilon = -\frac{d}{dt} N\phi$ $\varepsilon = -\frac{d}{dt} N\phi \text{ (1)}$ $\phi = BA\cos\theta \text{ (1)}$ $\theta = 2\pi ft \text{ (1)}$ Max emf when $\sin = 1 \text{ (1)}$ $\varepsilon = BAN \times 2\pi f \text{ (1)}$ $f = \frac{1}{T} \text{ (1)}$ $\varepsilon = 3.5 \times 0.3^2 \times 2000 \times \frac{1}{0.5} \text{ (1)}$ $\varepsilon = 7900 \text{ (1)}$
2 (b)	Both curve (1) 
2 (c)	Sin graph (1) Three cycles in 1.5 s (1) Axes labelled with quantity and units (1) 
3	Smooth curve (1) Axes labelled with quantity and units (1) Three cycles in 4.5 s (1) <p>A magnet entering coil (1)                      B magnet completely inside coil (1)                      C magnet leaving coil (1)                      Peak at A wider and lower amplitude than peak at C (1)</p> 
<b>Total</b>	

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