

# X069/11/02

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NATIONAL TUESDAY, 5 MAY  
QUALIFICATIONS 9.00 AM – 11.00 AM  
2015

PHYSICS  
INTERMEDIATE 2

## Read Carefully

Reference may be made to the Physics Data Booklet

- 1 All questions should be attempted.

## Section A (questions 1 to 20)

- 2 Check that the answer sheet is for Physics Intermediate 2 (Section A).
- 3 For this section of the examination you must use an **HB pencil** and, where necessary, an eraser.
- 4 Check that the answer sheet you have been given has **your name, date of birth, SCN** (Scottish Candidate Number) and **Centre Name** printed on it.  
Do not change any of these details.
- 5 If any of this information is wrong, tell the Invigilator immediately.
- 6 If this information is correct, **print** your name and seat number in the boxes provided.
- 7 There is **only one correct** answer to each question.
- 8 Any rough working should be done on the question paper or the rough working sheet, **not** on your answer sheet.
- 9 At the end of the exam, **put the answer sheet for Section A inside the front cover of your answer book.**
- 10 Instructions as to how to record your answers to questions 1–20 are given on page three.

## Section B (questions 21 to 31)

- 11 Answer the questions numbered 21 to 31 in the answer book provided.
- 12 **All answers must be written clearly and legibly in ink.**
- 13 Fill in the details on the front of the answer book.
- 14 Enter the question number clearly in the margin of the answer book beside each of your answers to questions 21 to 31.
- 15 Care should be taken to give an appropriate number of significant figures in the final answers to calculations.



## DATA SHEET

### *Speed of light in materials*

<i>Material</i>	<i>Speed in m/s</i>
Air	$3.0 \times 10^8$
Carbon dioxide	$3.0 \times 10^8$
Diamond	$1.2 \times 10^8$
Glass	$2.0 \times 10^8$
Glycerol	$2.1 \times 10^8$
Water	$2.3 \times 10^8$

### *Gravitational field strengths*

	<i>Gravitational field strength on the surface in N/kg</i>
Earth	10
Jupiter	26
Mars	4
Mercury	4
Moon	1.6
Neptune	12
Saturn	11
Sun	270
Venus	9

### *Specific latent heat of fusion of materials*

<i>Material</i>	<i>Specific latent heat of fusion in J/kg</i>
Alcohol	$0.99 \times 10^5$
Aluminium	$3.95 \times 10^5$
Carbon Dioxide	$1.80 \times 10^5$
Copper	$2.05 \times 10^5$
Iron	$2.67 \times 10^5$
Lead	$0.25 \times 10^5$
Water	$3.34 \times 10^5$

### *Specific latent heat of vaporisation of materials*

<i>Material</i>	<i>Specific latent heat of vaporisation in J/kg</i>
Alcohol	$11.2 \times 10^5$
Carbon Dioxide	$3.77 \times 10^5$
Glycerol	$8.30 \times 10^5$
Turpentine	$2.90 \times 10^5$
Water	$22.6 \times 10^5$

### *Speed of sound in materials*

<i>Material</i>	<i>Speed in m/s</i>
Aluminium	5200
Air	340
Bone	4100
Carbon dioxide	270
Glycerol	1900
Muscle	1600
Steel	5200
Tissue	1500
Water	1500

### *Specific heat capacity of materials*

<i>Material</i>	<i>Specific heat capacity in J/kg °C</i>
Alcohol	2350
Aluminium	902
Copper	386
Glass	500
Ice	2100
Iron	480
Lead	128
Oil	2130
Silica	1033
Water	4180

### *Melting and boiling points of materials*

<i>Material</i>	<i>Melting point in °C</i>	<i>Boiling point in °C</i>
Alcohol	-98	65
Aluminium	660	2470
Copper	1077	2567
Glycerol	18	290
Lead	328	1737
Iron	1537	2737

### *Radiation weighting factors*

<i>Type of radiation</i>	<i>Radiation weighting factor</i>
alpha	20
beta	1
fast neutrons	10
gamma	1
slow neutrons	3

SECTION A

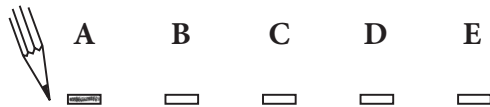
For questions 1 to 20 in this section of the paper the answer to each question is either A, B, C, D or E. Decide what your answer is, then, using your pencil, put a horizontal line in the space provided—see the example below.

**EXAMPLE**

The energy unit measured by the electricity meter in your home is the

- A kilowatt-hour
- B ampere
- C watt
- D coulomb
- E volt.

The correct answer is **A**—kilowatt-hour. The answer **A** has been clearly marked in **pencil** with a horizontal line (see below).



**Changing an answer**

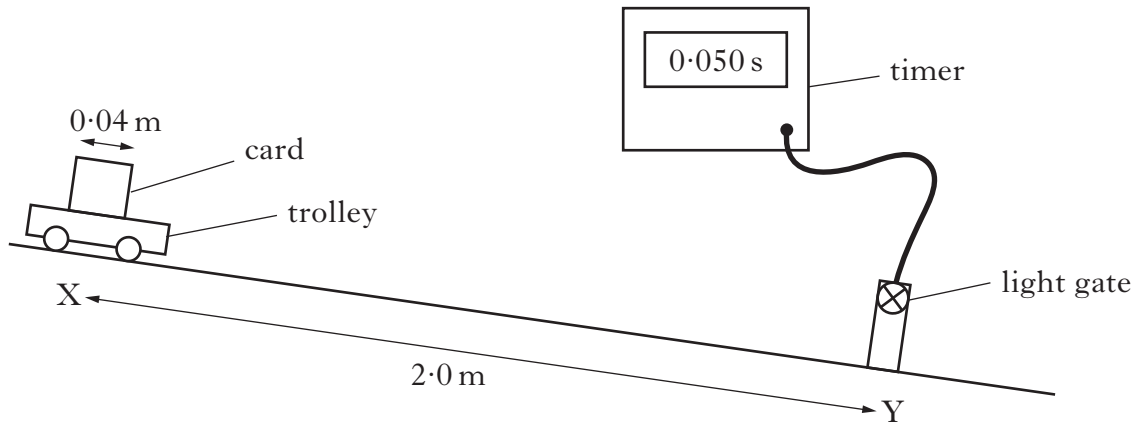
If you decide to change your answer, carefully erase your first answer and, using your pencil, fill in the answer you want. The answer below has been changed to **E**.



SECTION A

Answer questions 1–20 on the answer sheet.

1. A trolley is positioned 2.0 m from a light gate which is connected to a timer as shown.



The trolley is released from rest and takes 5.0 s to reach the light gate.

The time taken for the card on the trolley to pass through the light gate is 0.050 s.

The average speed of the trolley between X and Y is

- A 0.0020 m/s
- B 0.40 m/s
- C 0.80 m/s
- D 10.0 m/s
- E 40 m/s.

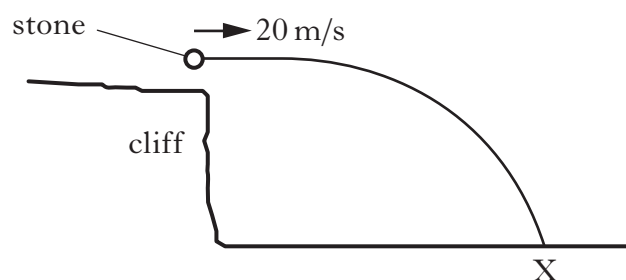
2. The table shows the velocities of three objects X, Y and Z over a period of 3 seconds. Each object is moving in a straight line.

<i>Time</i> (s)	0	1	2	3
<i>Velocity of X</i> (m/s)	2	4	6	8
<i>Velocity of Y</i> (m/s)	0	1	2	3
<i>Velocity of Z</i> (m/s)	0	2	5	9

Which of the following statements is/are correct?

- I X moves with constant velocity.
  - II Y moves with constant acceleration.
  - III Z moves with constant acceleration.
- A I only  
 B II only  
 C I and II only  
 D I and III only  
 E II and III only

3. A stone is projected horizontally from a cliff.



The initial speed of the stone is 20 m/s.

The stone hits the ground at X, 3.0 s after being projected.

The effect of air resistance can be ignored.

Which row in the table shows the horizontal speed and the vertical speed of the stone just before it hits the ground at X?

	<i>Horizontal speed</i> (m/s)	<i>Vertical speed</i> (m/s)
A	10	10
B	20	10
C	20	30
D	20	50
E	60	30

**[Turn over**

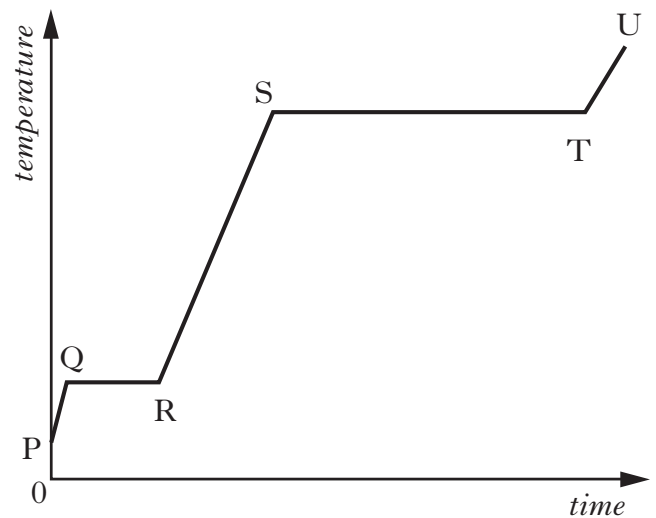
4. A person sits on a chair which rests on the Earth. The person exerts a downward force on the chair.



Which of the following is the reaction to this force?

- A The force of the chair on the person
  - B The force of the person on the chair
  - C The force of the Earth on the person
  - D The force of the chair on the Earth
  - E The force of the person on the Earth
5. Which of the following is a unit of work done?
- A  $\text{kg m/s}$
  - B  $\text{Nm}$
  - C  $\text{Nm/s}$
  - D  $\text{kg m/s}^2$
  - E  $\text{N/kg}$

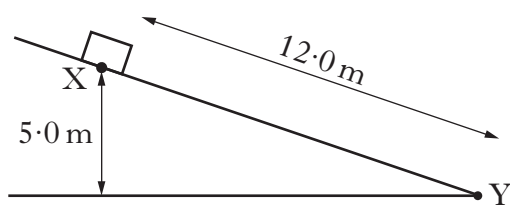
6. A solid substance is placed in an insulated container and heated. The graph shows how the temperature of the substance varies with time.



To calculate the specific latent heat of vaporisation of the substance, a student would use the time from section

- A PQ
- B QR
- C RS
- D ST
- E TU.

7. A box of mass  $0.40\text{ kg}$  slides down a frictionless slope.



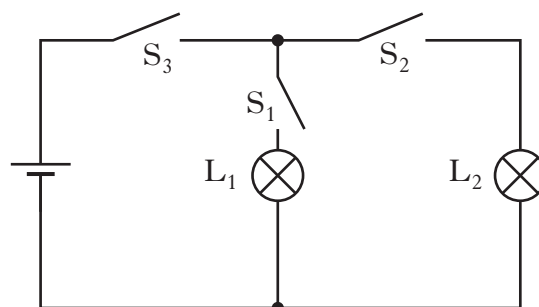
The box starts from rest at point X on the slope which is at a height of  $5.0\text{ m}$ . The kinetic energy of the box at point Y is

- A  $4.0\text{ J}$   
 B  $20\text{ J}$   
 C  $29\text{ J}$   
 D  $60\text{ J}$   
 E  $600\text{ J}$ .
8. Which of the following statements is/are correct?

- I The voltage of a battery is the number of joules of energy it gives to each coulomb of charge.  
 II A battery only has a voltage when it is connected in a complete circuit.  
 III Electrons are free to move within an insulator.

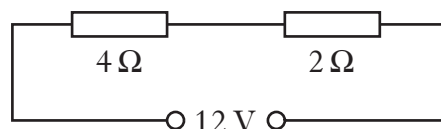
- A I only  
 B II only  
 C III only  
 D II and III only  
 E I, II and III

9. A circuit is set up as shown.



Which switch or switches must be closed to light lamp  $L_1$  **only**?

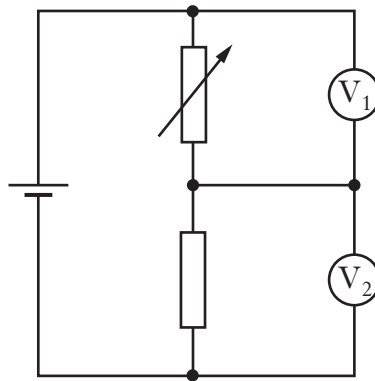
- A  $S_1$  only  
 B  $S_2$  only  
 C  $S_1$  and  $S_2$  only  
 D  $S_1$  and  $S_3$  only  
 E  $S_2$  and  $S_3$  only
10. Two resistors are connected in series with a  $12\text{ volt d.c.}$  supply.



The current in the  $2\ \Omega$  resistor is  $2\text{ A}$ . Which row in the table shows the current in the  $4\ \Omega$  resistor and the voltage across the  $4\ \Omega$  resistor?

	Current (A)	Voltage (V)
A	1	4
B	1	12
C	2	8
D	2	12
E	4	8

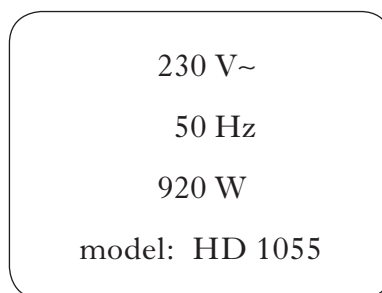
11. In the potential divider circuit shown, the resistance of the variable resistor is increased.



Which row in the table shows the effect of this on the voltmeter readings?

	<i>Reading on <math>V_1</math></i>	<i>Reading on <math>V_2</math></i>
A	decreases	decreases
B	increases	no change
C	decreases	increases
D	increases	decreases
E	decreases	no change

12. The rating plate on an electrical appliance is shown.

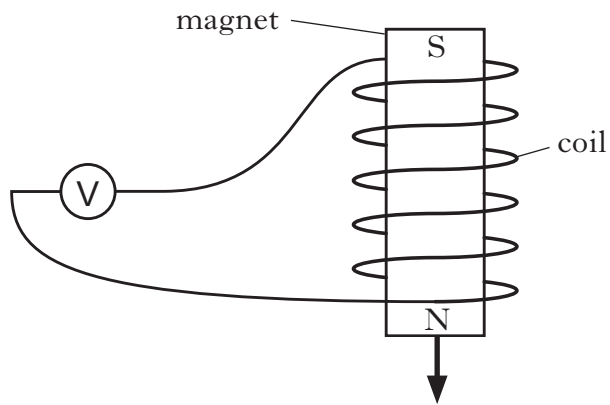


The resistance of this appliance is

- A 0.017  $\Omega$
- B 0.25  $\Omega$
- C 4.0  $\Omega$
- D 18.4  $\Omega$
- E 57.5  $\Omega$ .



13. A magnet is moved through a coil of wire as shown.



The induced voltage across the ends of the coil is zero when

- A the magnet is stationary in the coil
- B the number of turns in the coil of wire is increased
- C the field strength of the magnet is decreased
- D the magnet is moved in the opposite direction through the coil of wire
- E thinner wire is used.

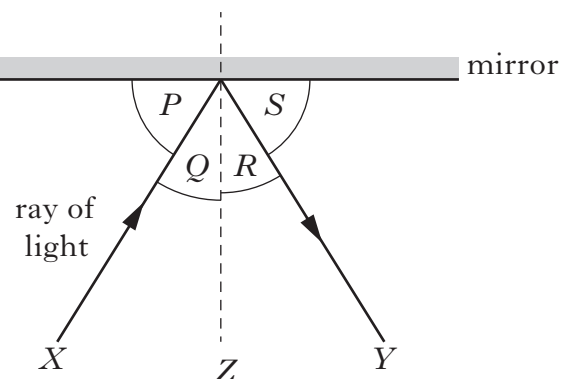
14. A student makes the following statements about different types of electromagnetic waves.

- I Light waves are transverse waves.
- II Radio waves travel at 340 m/s through air.
- III Ultraviolet waves have a longer wavelength than infrared waves.

Which of these statements is/are correct?

- A I only
- B I and II only
- C I and III only
- D II and III only
- E I, II and III

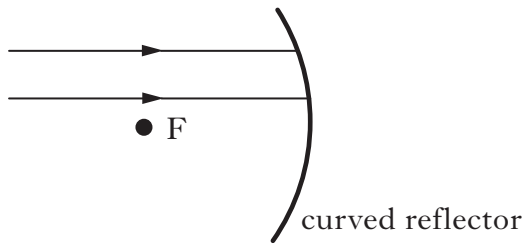
15. A ray of light is reflected by a mirror.



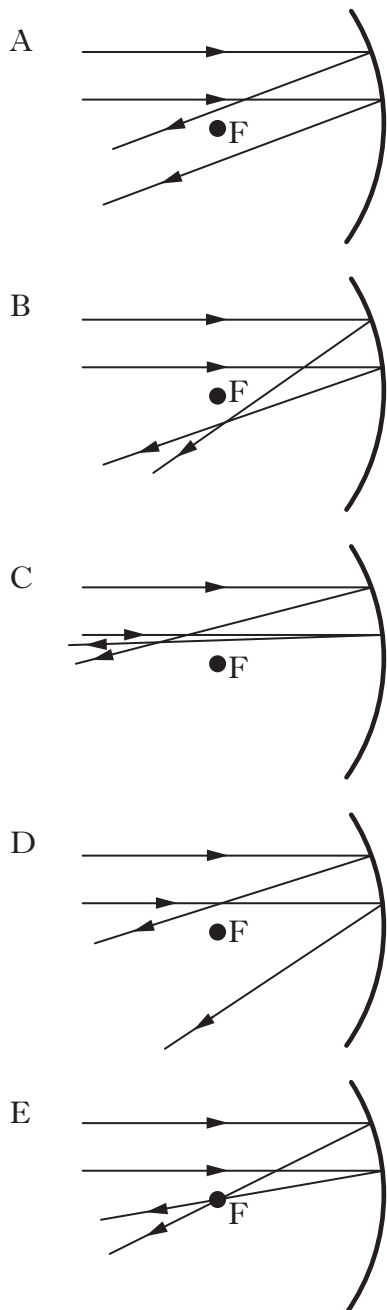
Which row in the table shows the angle of incidence, the angle of reflection and the normal?

	<i>Angle of incidence</i>	<i>Angle of reflection</i>	<i>Normal</i>
A	<i>Q</i>	<i>S</i>	<i>Z</i>
B	<i>Q</i>	<i>R</i>	<i>Z</i>
C	<i>P</i>	<i>R</i>	<i>Y</i>
D	<i>P</i>	<i>S</i>	<i>Y</i>
E	<i>P</i>	<i>R</i>	<i>X</i>

16. The diagram shows two rays of light incident on a curved reflector. The focal point, F, of the reflector is shown.



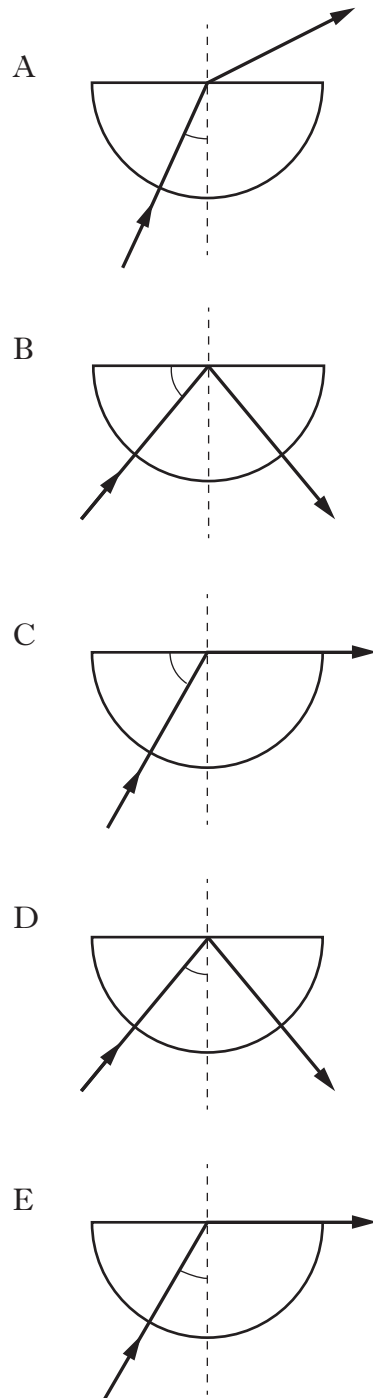
Which of the following diagrams shows the paths of the rays of light after reflection?



17. The diagrams show a light ray passing through a semi-circular glass block.

In each case one angle has been marked.

In which diagram is the critical angle marked?



18. Alpha radiation ionises an atom.  
Which statement describes what happens to the atom?

- A The atom splits in half.
- B The atom releases a neutron.
- C The atom becomes positively charged.
- D The atom gives out gamma radiation.
- E The atom releases heat.

19. A helium atom consists of electrons, neutrons and protons.

The nucleus contains

- A electrons only
- B neutrons and electrons
- C protons and electrons
- D protons and neutrons
- E protons, neutrons and electrons.

20. A sample of tissue is irradiated using a radioactive source.

A student makes the following statements.

The equivalent dose received by the tissue is

- I reduced by shielding the tissue with a lead screen.
- II increased as the distance from the source to the tissue is increased.
- III increased by increasing the time of exposure of the tissue to the radiation.

Which of the statements is/are correct?

- A I only
- B II only
- C I and II only
- D II and III only
- E I and III only

**Candidates are reminded that the answer sheet for Section A MUST be placed INSIDE the front cover of the answer book.**

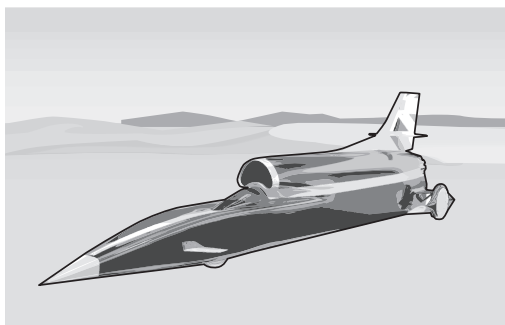
**[Turn over**

**SECTION B**

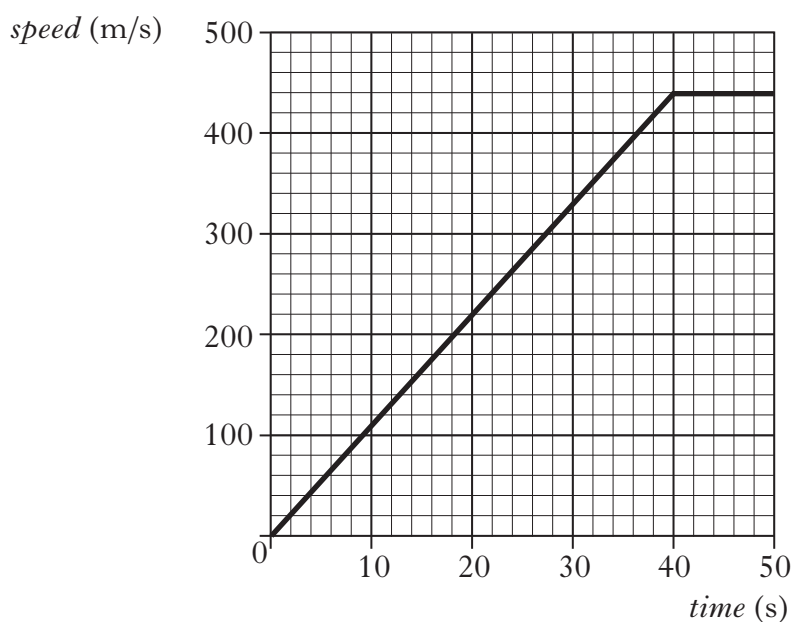
*Marks*

**Write your answers to questions 21–31 in the answer book.  
All answers must be written clearly and legibly in ink.**

21. A car fitted with a jet engine is used in a land speed record attempt.



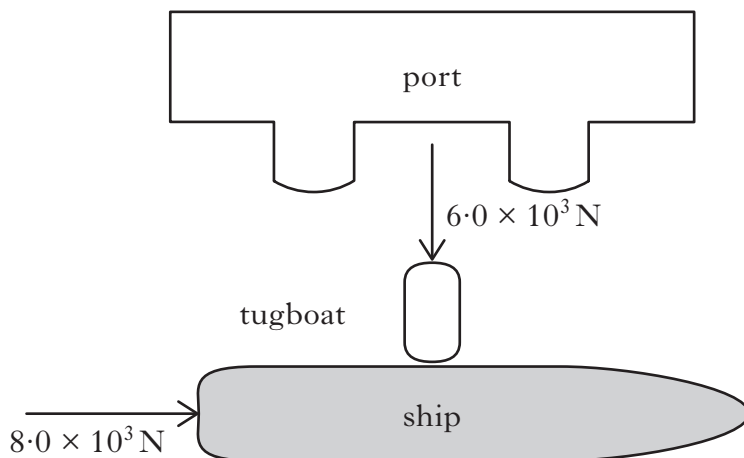
- (a) The graph shows the speed of the car for the first 50 seconds of a test run.



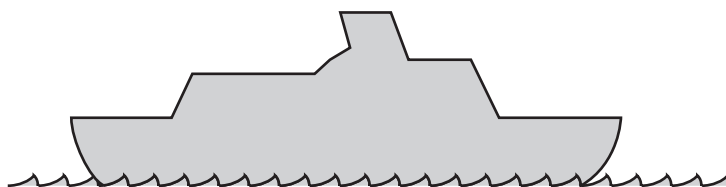
- (i) Calculate the acceleration of the car during the first 40 s. **2**
- (ii) Acceleration is a vector quantity. What is meant by a vector quantity? **1**
- (iii) Calculate the distance travelled by the car in the first 50 s. **2**
- (b) At the end of the run, the engine is switched off and parachutes attached to the car slow it down. **1**
- Explain how the parachutes slow down the car. **1**

**(6)**

22. A ship of mass  $5.0 \times 10^6$  kg leaves a port. Its engine produces a forward force of  $8.0 \times 10^3$  N. A tugboat pushes against one side of the ship as shown. The tugboat applies a pushing force of  $6.0 \times 10^3$  N.



- (a) (i) By scale drawing, or otherwise, determine the size of the resultant force acting on the ship. 2
- (ii) Determine the direction of the resultant force relative to the  $8.0 \times 10^3$  N force. 2
- (iii) Calculate the size of the acceleration of the ship. 2
- (b) Out in the open sea the ship comes to rest.

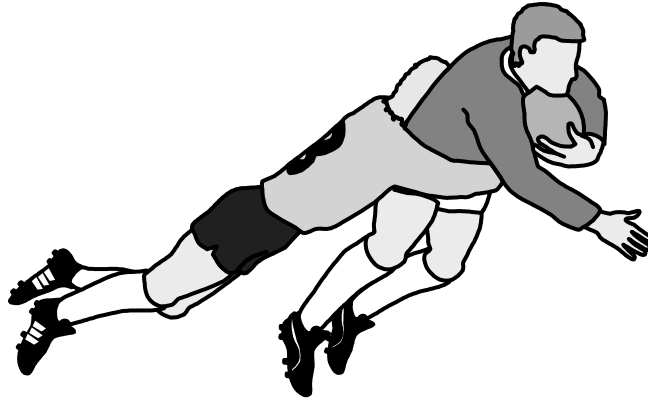


- (i) Draw a labelled diagram showing the vertical forces acting on the ship as it floats at rest in the water. 2
- (ii) Explain why the ship floats. 1
- (9)**

[Turn over

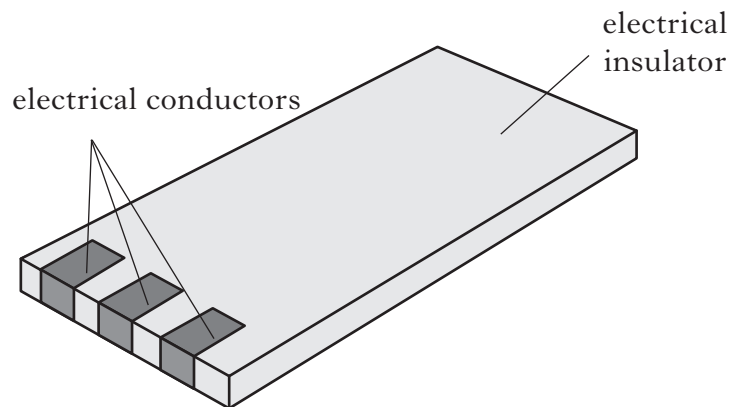
23. During a rugby match a player of mass  $80.0\text{ kg}$  tackles a stationary player of mass  $120.0\text{ kg}$ .

Immediately after the tackle, the players move together with a velocity of  $1.20\text{ m/s}$ .



- (a) State the Law of Conservation of Momentum. 1
- (b) Calculate the velocity of the  $80.0\text{ kg}$  player immediately before the tackle. 2
- (c) Calculate the total kinetic energy of the players after the tackle. 2
- (d) After the tackle, the two players come to rest over a distance of  $2.0\text{ m}$ .  
Calculate the average force acting on the players. 2
- (7)**

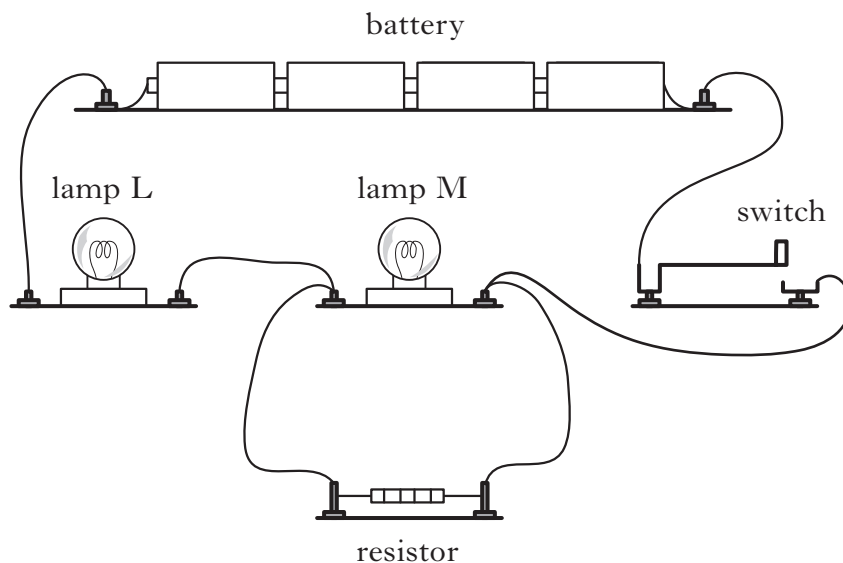
24. The picture shows a typical mobile phone battery.



- (a) (i) Give one example of a material which is an electrical conductor and one example of a material which is an electrical insulator. 1
- (ii) Explain the difference between conductors and insulators. 1
- (b) The battery is completely discharged. A current of 800 mA is then supplied for 2 hours. This charges the battery fully.
- (i) Calculate the total charge supplied to the battery. 2
- (ii) When in use the fully charged battery supplies a constant current of 50 mA.  
Calculate the time taken for the battery to completely discharge. 2
- (c) The mobile phone operates using radio waves of frequency  $2.0 \times 10^9$  Hz.  
Calculate the wavelength of these waves in air. 2
- (8)**

**[Turn over**

25. A student sets up the following circuit using a battery, two lamps, a switch and a resistor.



- (a) Draw a circuit diagram for this circuit using the correct symbols for the components. 3
- (b) Each lamp is rated 2.5 V, 0.50 A.  
Calculate the resistance of **one** of the lamps when it is operating at the correct voltage. 2
- (c) When the switch is closed, will lamp L be brighter, dimmer or the same brightness as lamp M?  
You **must** justify your answer. 2

(7)

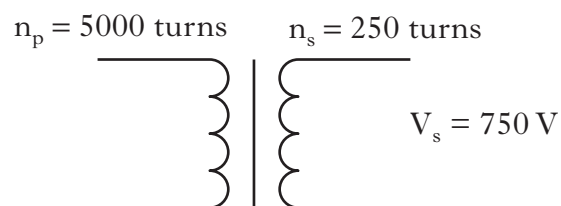


26. Some cities use electric trams driven by d.c. electric motors.

The trams are fitted with an electrical device which converts high voltage a.c. to lower voltage d.c..



- (a) Explain what *a.c.* and *d.c.* mean in terms of current. 2
- (b) The electrical device contains a transformer.



The output voltage of this transformer is 750 V.

There are 5000 turns in the primary coil and 250 turns in the secondary coil.

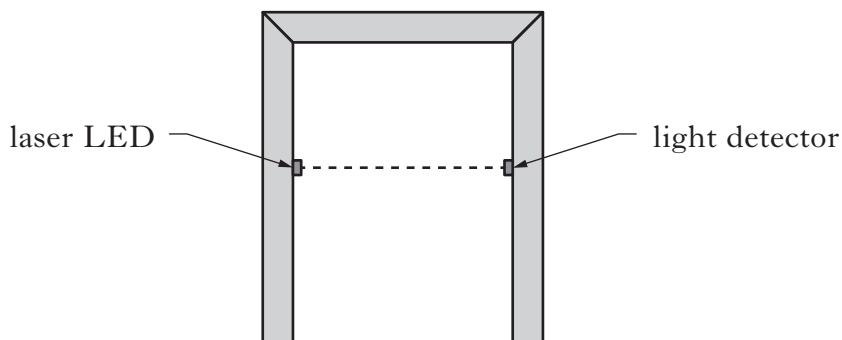
Calculate the input voltage to the transformer. 2

- (c) (i) A d.c. electric motor is operated by an input voltage of 700 V and input current of 150 A.  
Calculate the input power. 2
- (ii) The output power of the motor is 84 kW.  
Calculate the efficiency of the motor. 2

**(8)**

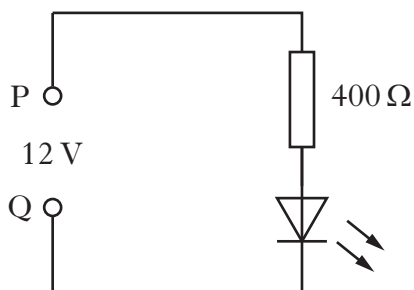
**[Turn over**

27. A security alarm sensor includes a laser LED which shines light across a doorway onto a light detector.



When the light beam is interrupted a buzzer sounds.

(a) The circuit for the laser LED is shown below.



Which terminal of the supply, P or Q, should be positive to enable the LED to light?

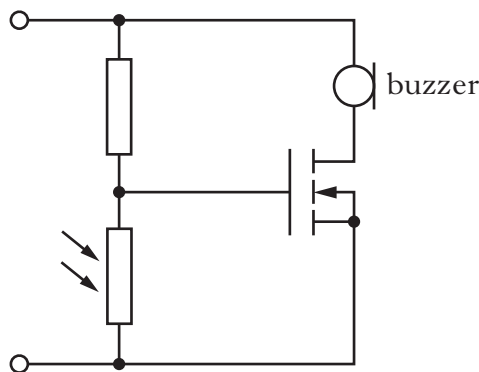
1

(b) The LED requires a  $400\ \Omega$  resistor in series in order to operate at its correct voltage of  $2.4\ \text{V}$ .

Calculate the current in the circuit.

3

(c) Part of the light detector circuit is shown below.



The laser light strikes the LDR.

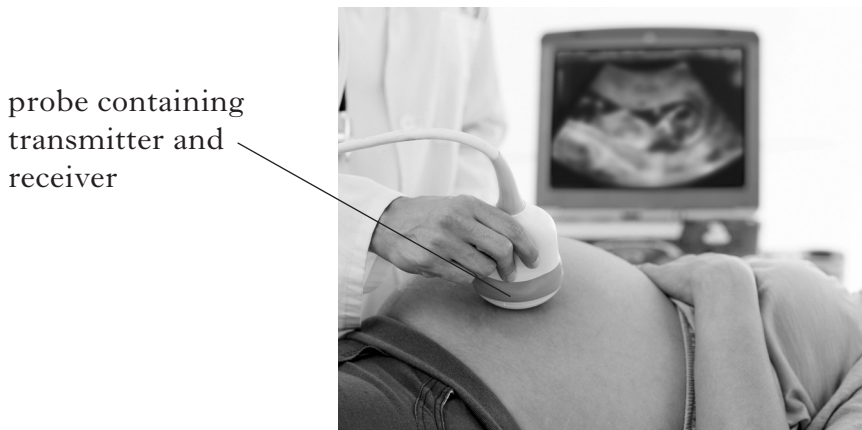
When the light is blocked the transistor switches on and the buzzer sounds.

Explain how the circuit operates to make the buzzer sound.

2

(6)

28. High frequency sound waves, known as ultrasound, are used to scan unborn babies.



A probe containing a transmitter sends ultrasound pulses through tissue and water towards the baby.

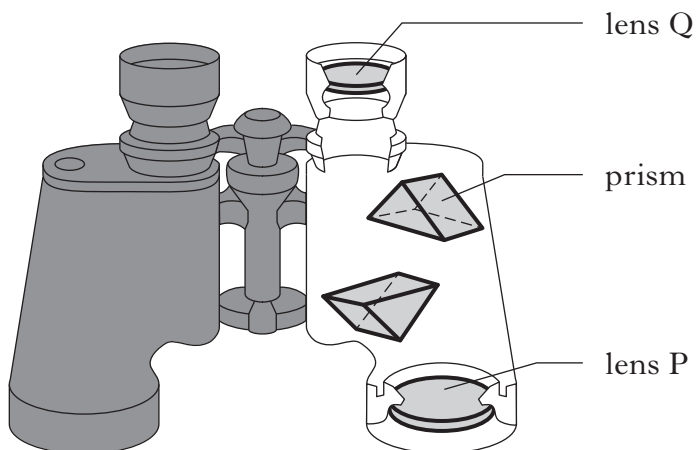
The pulses reflect off the baby and travel back to a receiver in the probe.

- (a) The time taken for one pulse to travel to the baby and back is  $5.4 \times 10^{-5}$  s.  
Use information from the data sheet to calculate the distance between the probe and the baby. 3
- (b) Is the wavelength of the ultrasound in the tissue longer, shorter or the same as it is in air?  
Explain your answer. 2
- (c) The electrical signal from the probe is very weak and needs to be amplified. This is done using an amplifier which has a gain of 500. The input voltage to the amplifier is 2 mV.  
Calculate the output voltage of the amplifier. 2

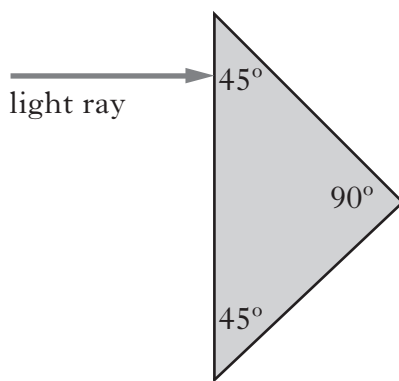
(7)

**[Turn over**

29. Some binoculars contain glass prisms as well as lenses.



(a) Light enters a glass prism as shown.



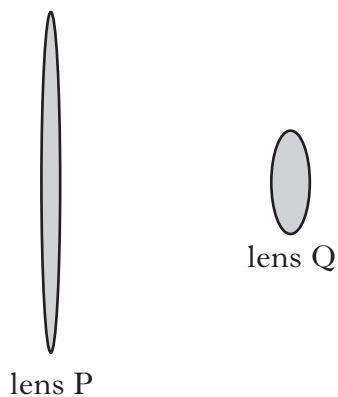
The critical angle for the glass is  $42^\circ$ .

Copy and complete the diagram to show the path of the light ray as it passes through the glass and into the air.

2

(b) Light is refracted by the binocular lenses.

The lenses P and Q are shown in the diagram below.

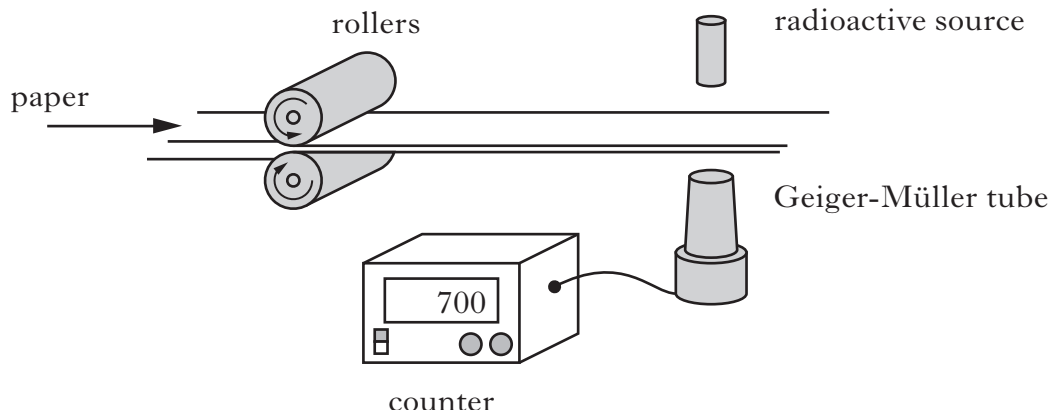


- (i) State what is meant by *refraction*. 1
- (ii) Which lens, P or Q, has the shorter focal length? 1
- (iii) Lens P has a power of 1.25 D.  
Calculate the focal length of this lens. 2

**[Turn over for Question 30 on *Page twenty two***

**DO NOT WRITE ON THIS PAGE**

30. A paper mill uses a radioactive source in a system to monitor the thickness of paper.



Radiation passing through the paper is detected by the Geiger-Müller tube. The count rate is displayed on the counter as shown. The radioactive source has a half-life that allows the system to run continuously.

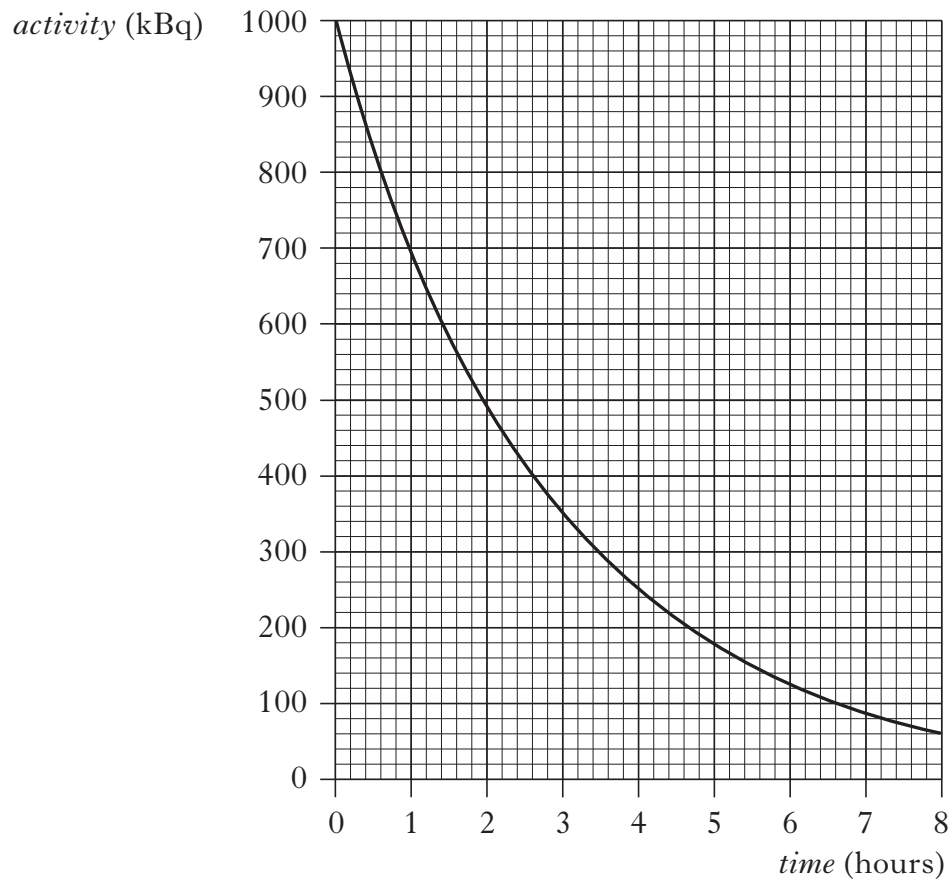
- (a) State what happens to the count rate if the thickness of the paper decreases. 1
- (b) The following radioactive sources are available.

<i>Radioactive Source</i>	<i>Half-life</i>	<i>Radiation emitted</i>
W	600 years	alpha
X	50 years	beta
Y	4 hours	beta
Z	350 years	gamma

- (i) Which radioactive source should be used? You **must** explain your answer. 2
- (ii) What is meant by the term *half-life*? 1
- (iii) State what is meant by a gamma ray. 1

30. (continued)

- (c) The graph below shows how the activity of another radioactive source varies with time.



Determine the half-life of this radioactive source.

2

(7)

[Turn over for Question 31 on *Page twenty four*

31. The moderator is one part of a nuclear reactor.



- (a) Explain the function of the moderator. 1
- (b) State the type of nuclear reaction that takes place in the reactor core. 1
- (c) In the reactor core, 1500 kg of coolant absorbs 184.5 MJ of heat energy. The coolant has a specific heat capacity of 1230 J/kg °C.  
Calculate the rise in temperature of the coolant assuming it does not change state. 2
- (d) A scientist receives an absorbed dose of 20 mGy from gamma radiation.
- (i) Calculate the equivalent dose received by the scientist. 2
- (ii) A sample of the gamma source has an activity of 3 MBq .  
Calculate the number of decays in one minute. 2
- (iii) The risk from biological harm from radiation exposure depends on the absorbed dose.  
State **one** other factor which contributes to the risk of biological harm. 1
- (9)**

[END OF QUESTION PAPER]

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