

MATRIC PHYSICAL SCIENCE PAPER 1 2009

INSTRUCTIONS AND INFORMATION

1. Write your name and/or examination number (and centre number if applicable) in the appropriate spaces in the ANSWER BOOK.
Answer ALL the questions.
2. Non-programmable calculators may be used.
3. Appropriate mathematical instruments may be used.
4. Number the answers correctly according to the numbering system used in this question paper.
5. Data sheets are attached for your use.
6. Give brief motivations, discussions, etc. where required.

SECTION A

Answer this section on the ANSWER SHEET provided.

QUESTION 1: ONE WORD/TERM ITEMS

Give ONE word/term for EACH of the following descriptions. Write only the word/term next to the question number (1.1–1.5).

- 1.1 the minimum amount of energy required to remove an electron from a metal surface (1)
- 1.2 the energy of a body due to state of motion (1)
- 1.3 the bending of light when it enters an optically more dense medium (1)
- 1.4 the product of the magnetic field strength inside a single coil of a conductor and the area enclosed by the coil (1)
- 1.5 a material that increases the capacitance of a capacitor when placed between the parallel plates of the capacitor (1)

[5]

QUESTION 2: CORRECTING FALSE STATEMENTS

The statements in questions 2.1–2.5 are FALSE. Correct the statements.

- 2.1 When holding a 1 kg mass in your hand, with your palm facing upwards, the reaction to the weight of the 1 kg mass is the normal force of the hand on the mass. (2)
- 2.2 The refraction and diffraction of light both involve light “bending” when it passes into an optically denser medium. (2)
- 2.3 If two resistors of 3 Ω and 5 Ω respectively are connected in parallel in a closed circuit (with charge flowing), the potential difference across the 3 Ω resistor will be higher than the potential difference across the 5 Ω resistor. (2)
- 2.4 For the “lasing” process to be initiated in a laser, all electrons in the laser material must occupy higher energy levels than in their normal state. (2)
- 2.5 The wavelength of a “matter wave” – the waves associated with moving particles – is proportional to the momentum of the particle. **This section is not examinable.** (2)

[10]

QUESTION 3: MULTIPLE-CHOICE QUESTIONS

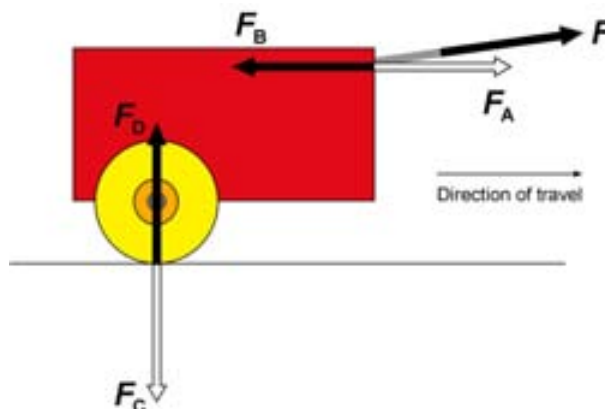
Four possible answers are provided for each of the following questions. Choose the correct answer and mark (X) the appropriate block (A–D) next to the question number (3.1–3.5). There is only ONE correct answer for each question.

- 3.1 Two trolleys, A (2 kg) and B (4 kg), stand on a frictionless, horizontal surface. They are connected by a rubber band. The two trolleys are then pulled apart and the rubber band stretches. When the trolleys are released they move towards each other, collide and lock together. After the collision the two trolleys, which are now joined, will

- A move in the direction of A, the 2 kg trolley.
- B move in the direction of B, the 4 kg trolley, with a decreased velocity.
- C move in the direction of B, the 4 kg trolley, with an increased velocity.
- D remain stationary.

(2)

3.2



A small cart is pulled along a rough road by a force, F . Consider these statements:

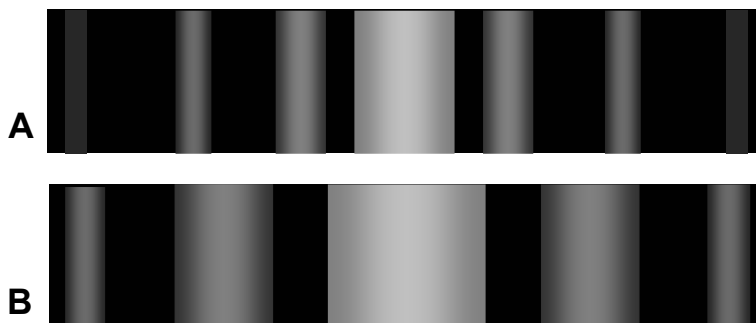
- I F_A is the component of force F in the direction of travel.
- II F_C and F_D form an action-reaction pair representing, respectively, the weight of the cart and the normal force of reaction that the ground exerts on the wheel.
- III The resultant force that causes the cart to move can be given by the expression $F_A - \mu F_D$, where μ is the appropriate coefficient of friction.

Which of the above statements is/are TRUE?

- A Only I
- B Only II
- C Both I and III
- D Both II and III

(2)

- 3.3 The diagrams below represent the diffraction bands formed by light falling on a single slit. Light of each of two different colours was directed at the slit consecutively. The diffraction patterns A and B were obtained for the two different colours.

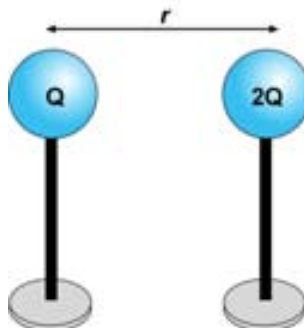


The colours of light used could have been:

- A green light for A and blue light for B
- B red light for A and yellow light for B
- C yellow light for A and green light for B
- D green light for A and red light for B

(2)

- 3.4 The centres of two identical spheres are a distance r apart. The spheres carry charges of Q and $2Q$ respectively, as shown in the diagram below. The magnitude of the electrostatic force each sphere exerts on the other is F .

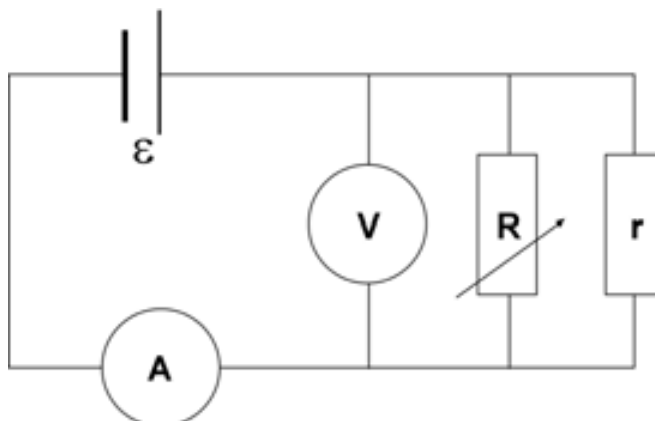


The two spheres are brought into contact and then separated to a distance $r/2$ apart, i.e. they are now one half of the original distance apart. The magnitude of the new force between the charges is

- A $F/2$ if the original charges were oppositely charged.
- B F
- C $4F$ if the original charges were both positive.
- D $8F$ if the original charges were both negative.

(2)

- 3.5 In the circuit represented below, the resistance of the variable resistor is decreased.



How would this decrease affect the readings on the voltmeter and ammeter?

	Voltmeter reading	Ammeter reading
A	unchanged	decreases
B	decreases	increases
C	increases	unchanged
D	unchanged	increases

(2)

[10]

TOTAL SECTION A: 25

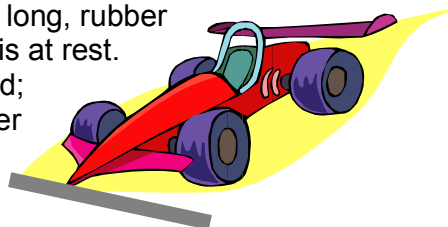
SECTION B

INSTRUCTIONS AND INFORMATION

- The formulae and substitutions must be shown in ALL calculations.
- Round your answers to TWO decimal places.

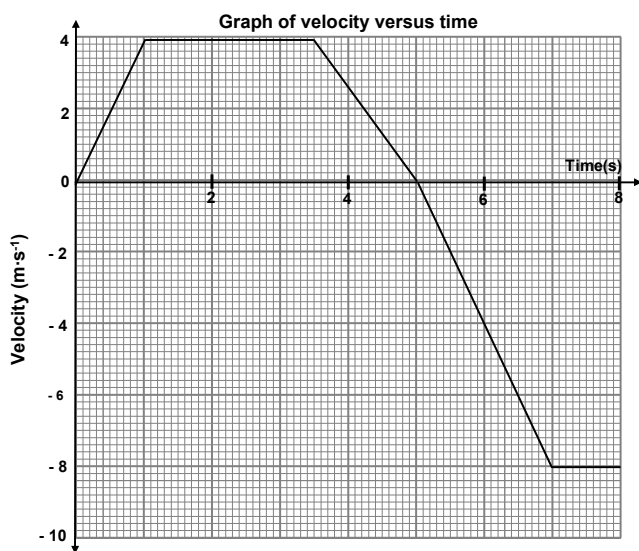
QUESTION 4

An electrical toy racing car is placed at the start line on a long, rubber track. Aziz holds the control in his hands. Initially the toy is at rest. When Aziz pushes a lever forward, the car moves forward; when he pulls the lever back, the car reverses. The further backwards or forwards Aziz moves the control lever, the faster the car moves.



The following velocity–time graph was obtained for the car's motion over a period of 8 seconds.

The following velocity-time graph was obtained for the car's motion over a period of 8 seconds.



Use the information on the graph to answer the following questions:

- 4.1 Calculate the acceleration of the car between times $t = 5$ s and $t = 7$ s. (2)
- 4.2 When does the car move at a speed of $2,6 \text{ m s}^{-1}$? (2)
- 4.3 Describe the motion of the car between 4 s and 6 s. (3)
- 4.4 Where is the car relative to the start line 8 s after it started moving? (4)

[11]

QUESTION 5

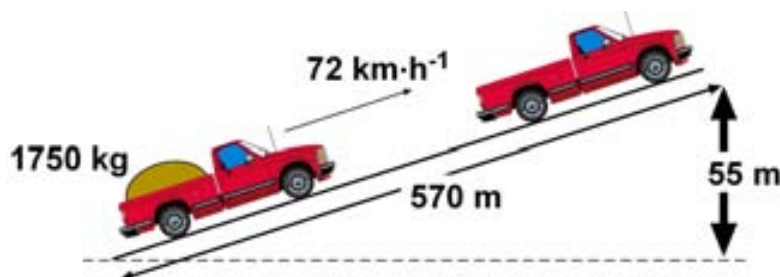
A 400 g ball is thrown vertically into the air with a velocity of $28,69 \text{ m}\cdot\text{s}^{-1}$. The ball takes 5,84 s to return to the ground.

On striking the ground, the ball bounces and reaches a height that is exactly half the maximum height attained during the throw.

- 5.1 Calculate the maximum height attained by the ball when thrown upwards. (3)
- 5.2 Determine the velocity of the ball the instant before it strikes the ground. (2)
- 5.3 Calculate the velocity of the ball the instant after bouncing off the ground. (4)
- 5.4 If the average force exerted by the ground on the ball as it bounces is 103 N, for how long are the ball and ground in contact? You may ignore the effects of friction. (6)

[15]**QUESTION 6**

A loaded bakkie with a total mass of 1750 kg travels up an uphill road. The bakkie maintains a constant speed of $72 \text{ km}\cdot\text{h}^{-1}$ during the 570 m climb. When it reaches the highest point on the road, the bakkie has risen 55 m above the start of the slope.



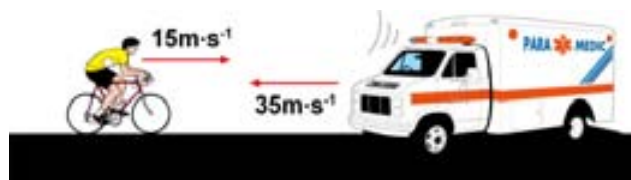
- 6.1 If the work done to overcome friction is $5,84 \times 10^6 \text{ J}$, calculate the average power developed by the bakkie's engine during the climb. (3)
- 6.2 What is the resultant force on the bakkie at a point halfway up the 570 m climb? Explain your answer. (2)
- 6.3 After the bakkie has been off-loaded its empty mass is 1100 kg. On its return journey the bakkie accelerates from $72 \text{ km}\cdot\text{h}^{-1}$ at the top to $90 \text{ km}\cdot\text{h}^{-1}$ at the bottom of the same slope. If the average frictional force on the bakkie during the downhill journey is $6,44 \times 10^3 \text{ N}$, how much work does the engine do while the bakkie is accelerating? (7)

[12]

QUESTION 7

7.1 Describe the Doppler effect.

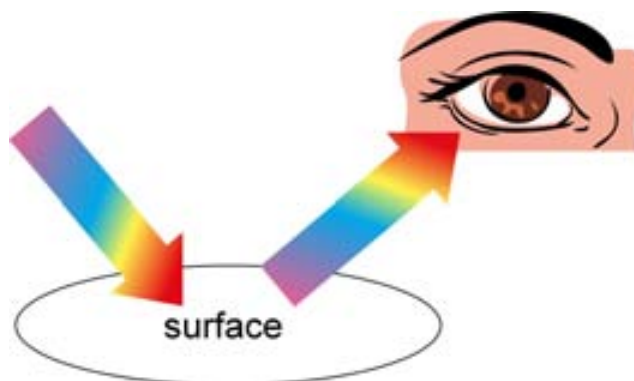
(2)



A cyclist pedals along a road at a speed of $15 \text{ m} \cdot \text{s}^{-1}$ when an ambulance comes directly towards him at a steady speed of $35 \text{ m} \cdot \text{s}^{-1}$. The ambulance driver turns on the siren to warn the cyclist of his approach and the cyclist stops immediately when he hears the siren. The ambulance maintains its steady speed. The speed of sound is $330 \text{ m} \cdot \text{s}^{-1}$.

7.2 What does the cyclist notice about the siren sound as he comes to a halt? (1)

7.3 If the frequency of the continuous blast from the siren is 400 Hz, what change in frequency will the cyclist observe as the ambulance passes him? (4)

[7]**QUESTION 8**

In the table below the columns represent the colour of the light falling on a surface. The rows represent the differently pigmented (coloured) surfaces that the incident light falls on.

Give the observed SURFACE COLOURS in each case, i.e. 8.1 to 8.8.

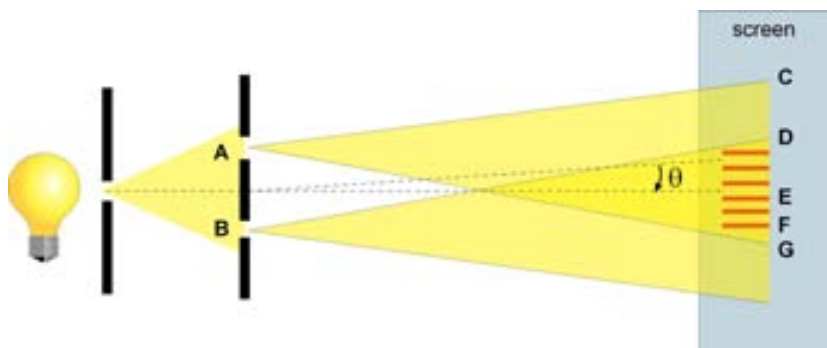
	<i>Light colour →</i>	GREEN	MAGENTA	YELLOW
<i>Surfaces →</i>	CYAN	8.1	8.4	8.6
	BLUE	<i>Black</i>	<i>Blue</i>	8.7
	YELLOW	8.2	8.5	<i>Yellow</i>
	RED	8.3	<i>Red</i>	8.8

$[8 \times \frac{1}{2} = 4]$

QUESTION 9

In 1801 Thomas Young demonstrated the phenomenon of interference of light using a single source of monochromatic light (S in the diagram) to illuminate two thin slits (A and B in the diagram below). The equation that describes the pattern formed in Young's

experiment when two waves interfere is given as: $\sin \theta = m \frac{\lambda}{a}$



Refer to the diagram when answering the following questions:

- 9.1 Which is/are regarded as the source(s) of light in Young's experiment? (1)
- 9.2 Why is there an interference pattern in the space between D and G, but not between C and D? (2)
- 9.3 Explain why we find a bright band at E (known as the central maximum), but a dark band at F. (2)
- 9.4 What is the value of m in the equation for the central maximum? Explain your answer using your knowledge of basic trigonometry. (2)
- 9.5 What is the value of m for the angle θ shown in the diagram? (1)
- 9.6 Write down the missing words, indicated by the numbers, in the following passage.

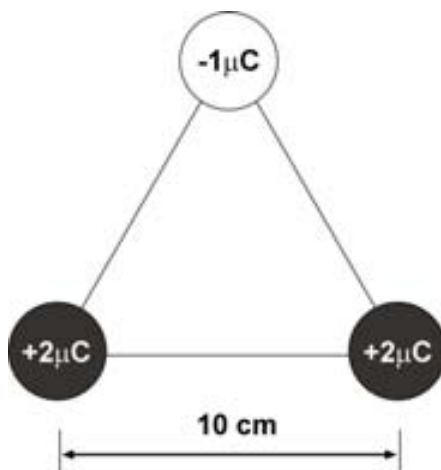
"When a wave (9.6.1) strikes a narrow gap, every point on the wavefront acts as a source of secondary wavelets. This "bending" of a wavefront by an edge is known as (9.6.2). Thus the pattern produced by a single slit is actually an (9.6.3) pattern with alternating bright and dark bands similar to those found in a Young's experiment. Patterns formed in this kind of experiment with light are at their clearest when the width of the gap/slit used is of a similar length as that of the (9.6.4) of the monochromatic light source."

(4 x 1)

[12]

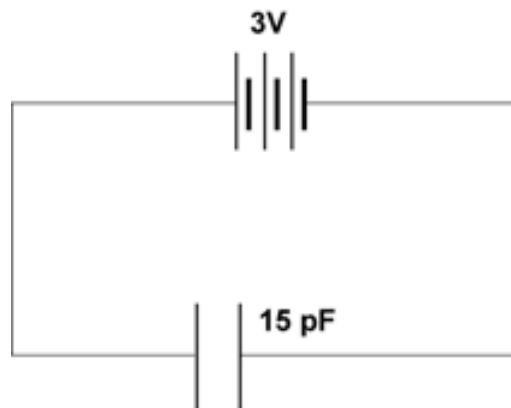
QUESTION 10

Three identical charged metal spheres are positioned at the vertices of an equilateral triangle, as shown in the diagram. The charges on the three spheres are $+2\ \mu\text{C}$, $+2\ \mu\text{C}$ and $-1\ \mu\text{C}$, as shown. The centres of all the spheres are 10 cm apart.



- 10.1 What is the magnitude of the forces that the $-1\ \mu\text{C}$ charge and one of the $+2\ \mu\text{C}$ charges exert on each other? (3)
- 10.2 Draw a force diagram showing the direction and magnitude of the forces that act on the $-1\ \mu\text{C}$ charge and the $+2\ \mu\text{C}$ on the LEFT side of the triangle, if the $+2\ \mu\text{C}$ charge on the RIGHT side of the triangle is removed. (2)
- 10.3 The two spheres carrying the $+2\ \mu\text{C}$ charges are held in position and the $-1\ \mu\text{C}$ charge is replaced by a $+1\ \mu\text{C}$ charge.
- 10.3.1 Draw a free-body diagram to show the direction and approximate size of the resultant force that acts on the $+1\ \mu\text{C}$ charge. (2)
- 10.3.2 State whether the magnitude of the force on the $+1\ \mu\text{C}$ charge will be less than 1 N, greater than 2 N or greater than 5 N. (1)

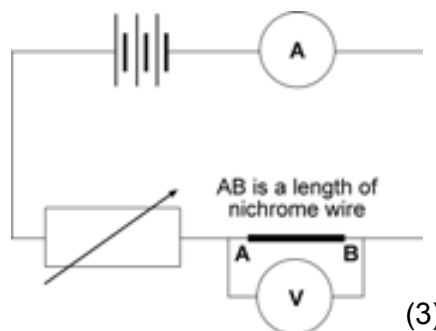
[8]

QUESTION 11

- 11.1 How much charge can a 15 pF capacitor hold when connected in series with a 3,0 V battery? (2)
- 11.2 How many electrons make up this charge? (2)
- 11.3 How will a 30 pF capacitor differ from a 15 pF capacitor if they are both made from identical materials and if the gap between the capacitor plates is also identical? (1)

[5]**QUESTION 12**

Sipho connected this circuit to investigate whether a 500 mm length of nichrome wire, with a diameter of 0,1 mm, obeys Ohm's Law.

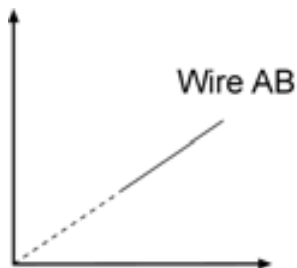


- 12.1 State Ohm's law. (3)
- 12.2 What could Sipho's hypothesis have been for this experiment? (1)
- 12.3 What is the purpose of the variable resistance in the experimental circuit? (1)
- 12.4 Sipho adjusts the current in the circuit and measures the potential difference across AB for each current value I , i.e. the ammeter readings. Explain which variable Sipho should plot on the vertical axis of his graph. (2)

Sipho takes the following readings:

Ammeter reading (A)	Voltmeter reading (V)
0,8	1,0
1,8	2,2
2,2	2,7
2,8	3,4

- 12.5 He plots his experimental data on a graph and finds that he gets a straight line which, when extrapolated to lower values of I , is found to pass through the origin.

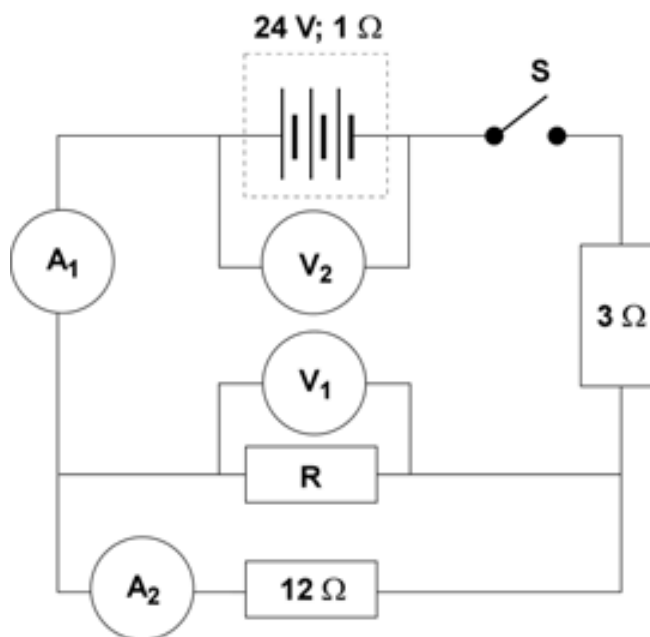


- 12.5.1 What quantity does the slope of the graph represent? (1)
- 12.5.2 Use the raw data in the table to calculate the average slope of the graph to one decimal place. (1)
- 12.5.3 Was the nichrome wire used in Sipho's experiment ohmic? Explain your answer and mention one variable that must be controlled. (2)
- 12.6 What will the approximate resistance of a 1 m length of nichrome wire with a diameter of 0,1 mm be? (1)
- 12.7 Estimate the resistance of a 500 mm length of nichrome wire with a diameter of 0,2 mm. (2)

[14]

QUESTION 13

Arnold and Mary construct a circuit as shown in the diagram below. The circuit contains a fresh, fully charged 24 V battery with an internal resistance of $1\ \Omega$.

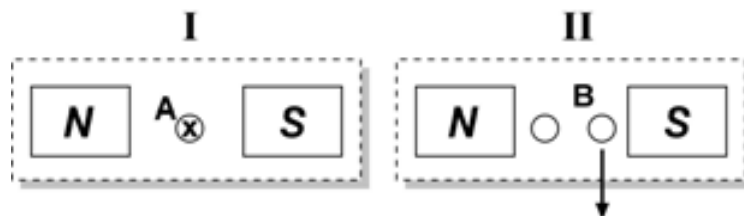


When the switch, S, is closed Mary reads the ammeter A_1 and records a current of 3 A.

- 13.1 Using this value of the reading on A_1 , i.e. 3A, calculate the
- 13.1.1 value of the unknown resistance, R (4)
 - 13.1.2 the reading on the voltmeter V_1 (3)
 - 13.1.3 the reading on the voltmeter V_2 (3)
 - 13.1.4 the reading on the ammeter A_2 (3)
 - 13.1.5 the energy dissipated per second in the battery when charge is flowing in the circuit. (3)
- 13.2 The switch, S, remains closed and charge is allowed to flow in the circuit for a long time. State whether the following readings will INCREASE, DECREASE or REMAIN UNCHANGED:
- 13.2.1 A_1 (1)
 - 13.2.2 A_2 (1)
 - 13.2.3 V_1 (1)
 - 13.2.4 V_2 (1)
- 13.3 Explain the underlying cause for any changes in the circuit as the battery gets older. (1)
- [21]**

QUESTION 14

- 14.1 Diagrams I and II each shows two magnet poles and the end-view of a conducting coil situated between the poles. The diagrams illustrate the principle on which electric motors and generators are based. The current in the coils is conventional current.



Use the appropriate rule to determine

- 14.1.1 the direction of the force (“up” or “down”) on the conductor at A (1)
 - 14.1.2 the direction of the current (“in” or “out”) at B if the applied force on the conductor is downward. (1)
- 14.2 Which of the two diagrams illustrate the basis for an AC generator? (1)

14.3 An ammeter records a reading of 24 A for the current in an AC circuit.

14.3.1 What is the term used to describe the value of this reading? (1)

14.3.2 What is the highest value the current actually attains in the positive half of the AC cycle in this circuit? (Calculation to one decimal place.) (2)

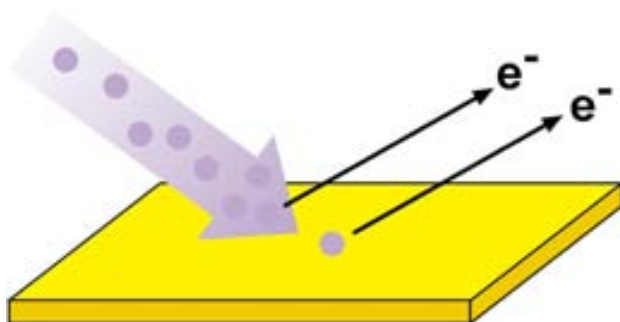
14.3.3 What is the maximum variation of the current for a single AC cycle? (1)

14.3.4 What is the term used to describe the value calculated in 13.3.3? (1)

14.3.5 Can one calculate the rate at which the current in this circuit alternates using the information given? Explain your answer. (1)

[9]

QUESTION 15



15.1 What is the phenomenon called whereby electrons are removed from a metal surface by the action of light? (1)

15.2 Yellow light has a wavelength of approximately 590 nm. The minimum energy required for a photon to remove an electron from zinc metal is $6,89 \times 10^{-19}$ J. Determine whether a beam of yellow light will liberate electrons from the surface of a clean piece of zinc metal. (5)

15.3 If the intensity of the yellow light on the zinc metal is increased, explain the effect this will have on the number of photoelectrons. (1)

[7]

TOTAL FOR SECTION B: 125

GRAND TOTAL: 150

DATA FOR MATRIC PHYSICAL SCIENCES PAPER 1**TABLE 1: PHYSICAL CONSTANTS**

NAME	SYMBOL	VALUE
Acceleration due to gravity	g	9,80 m·s ⁻²
Speed of light in a vacuum	c	3,00 x 10 ⁸ m·s ⁻¹
Planck's constant	h	6,63 x 10 ⁻³⁴ J·s
Gravitational constant	G	6,67 x 10 ⁻¹¹ N·m ² ·kg ⁻²
Coulomb's constant	k	9,00 x 10 ⁹ N·m ² ·C ⁻²
Charge on electron	e	-1,60 x 10 ⁻¹⁹ C
Electron mass	m _e	9,11 x 10 ⁻³¹ kg
Permittivity of free space	ε ₀	8,85 x 10 ⁻¹² F·m ⁻¹
Permeability of free space	μ ₀	4 π x 10 ⁻⁷ T·m·A ⁻¹

TABLE 2: FORMULAE**MOTION**

$v_f = v_i + a \Delta t$	$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$ or $\Delta y = v_i \Delta t + \frac{1}{2} a \Delta t^2$
$v_f^2 = v_i^2 + 2a\Delta x$ or $v_f^2 = v_i^2 + 2a\Delta y$	$\Delta x = \left(\frac{v_f + v_i}{2} \right) \Delta t$ or $\Delta y = \left(\frac{v_f + v_i}{2} \right) \Delta t$

FORCE

$F_{net} = ma$	$p = mv$
$F\Delta t = \Delta p = mv_f - mv_i$	$F_g = mg$

WORK, ENERGY AND POWER

$W = F\Delta x \cos \theta$	$U = E_p = mgh$
$K = E_k = \frac{1}{2} mv^2$	$W = \Delta K = \Delta E_k = E_{kf} - E_{ki}$
$P = \frac{W}{\Delta t}$	$P = Fv$

WAVES, LIGHT AND SOUND

$v = f\lambda$ or $v = v\lambda$	$T = \frac{1}{f}$ or $T = \frac{1}{v}$
$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$	$E = hf$ or $E = h\nu$ or $E = h\frac{c}{\lambda}$

$\lambda = \frac{h}{mv}$	$\sin \theta = \frac{m\lambda}{a}$
$hf = W_0 + \frac{1}{2}mv^2$	

MATTER AND MATERIALS

$F = k\Delta x$	$\text{Stress} = \frac{F}{A}$
$\text{Strain} = \frac{\Delta x}{\ell}$	

ELECTRICITY AND MAGNETISM

$I_{\text{rms}} = \frac{I_{\text{max}}}{\sqrt{2}}$ $V_{\text{rms}} = \frac{V_{\text{max}}}{\sqrt{2}}$	$\varepsilon = -N \frac{\Delta \Phi}{\Delta t}$
$\Phi = BA$	$P_{\text{average}} = V_{\text{rms}} I_{\text{rms}}$ $P_{\text{average}} = \frac{V_{\text{rms}}^2}{R}$ $P_{\text{average}} = I_{\text{rms}}^2 R$

ELECTROSTATICS

$F = \frac{kQ_1 Q_2}{r^2}$	$E = \frac{kQ}{r^2}$
$E = \frac{V}{d}$	$U = \frac{kQ_1 Q_2}{r}$
$E = \frac{F}{q}$	$Q = It$
$C = \frac{Q}{V}$	$C = \frac{\varepsilon_0 A}{d}$

ELECTRIC CIRCUITS

$R = \frac{V}{I}$	$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$
$R_s = R_1 + R_2 + \dots$	$\text{emf} (\varepsilon) = I(R + r)$