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GRADE 12

SEPTEMBER 2022

TECHNICAL SCIENCES P1

MARKS: 150

TIME: 3 hours

This question paper consists of 17 pages, including 3 data sheets.

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions in the ANSWER BOOK.
2. Write your NAME and SURNAME in the appropriate spaces on the ANSWER BOOK.
3. Start EACH question on a NEW page in the ANSWER BOOK.
4. Number the answers correctly according to the numbering system used in this question paper.
5. You may use a non-programmable calculator.
6. LEAVE a line open between two subsections, i.e. between QUESTION 2.1 and QUESTION 2.2.
7. You are advised to use the attached DATA SHEETS.
8. Show ALL formulae and substitutions in ALL calculations.
9. Round off your final numerical answers to a minimum of TWO decimal places.
10. Give brief motivations, discussions, etc. where required.
11. Write neatly and legibly.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are provided as answers to the following questions. Choose the answer and write only the correct letter (A–D) next to the question numbers (1.1 to 1.10) in the ANSWER BOOK, for example 1.11 D.

1.1 Acceleration is defined as the rate of change of ...

- A speed.
- B velocity.
- C position.
- D distance.

(2)

1.2 A stationary minibus taxi has its sliding door open. When the taxi driver accelerates and then stops suddenly the sliding door closes without being pushed.

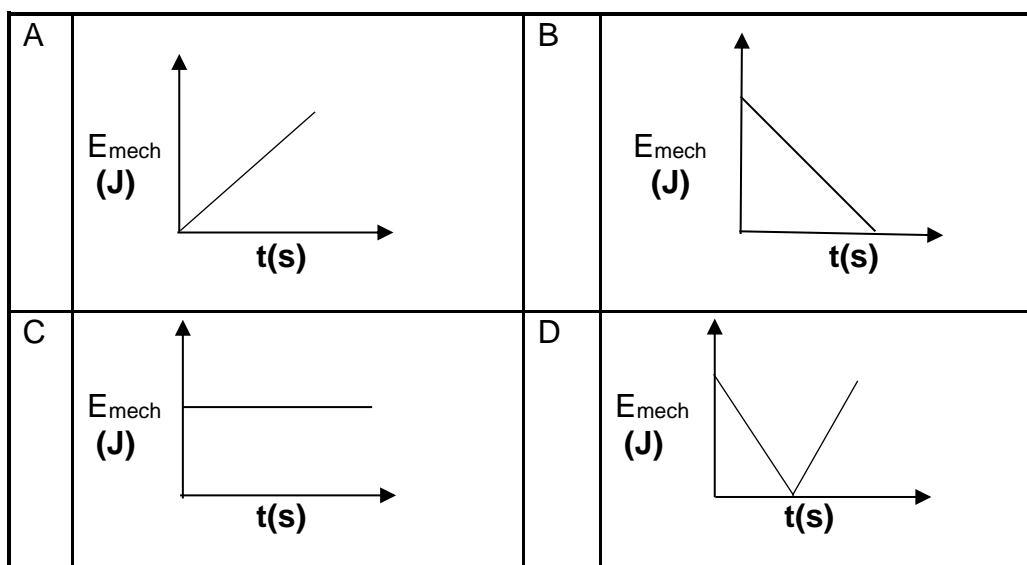
The closing of the sliding door when the taxi stops is an illustration of ...

- A Hooke’s Law.
- B Newton’s First Law.
- C Newton’s Second Law.
- D Newton’s Third Law.

(2)

1.3 A ball is dropped and falls vertically downwards. Ignore air resistance.

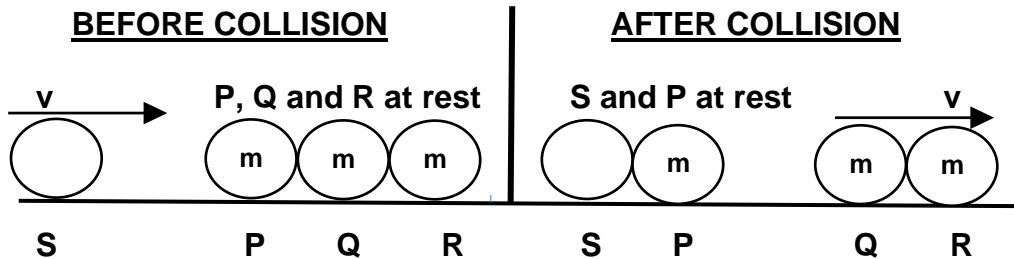
Which ONE of the following graphs is CORRECT about mechanical energy (E_{mech}) of the ball versus time (t)?



(2)

- 1.4 Three metal spheres **P**, **Q** and **R** of equal mass **m**, initially at rest are in contact with each other on a frictionless table. A fourth metal sphere **S** moving with velocity **v** to the right collides with sphere **P** and comes to rest.

Immediately after the collision spheres **Q** and **R** move together with a combined kinetic energy equal to **E**. Sphere **P** remains at rest.



The collision is ELASTIC.

What is the mass and kinetic energy of sphere **S** just before the collision if both spheres **Q** and **R** move at velocity **v** after the collision?

	MASS OF SPHERE S	KINETIC ENERGY OF SPHERE S JUST BEFORE THE COLLISION
A	2m	E
B	m	2E
C	$\frac{1}{2} m$	$\frac{1}{2} E$
D	2m	2E

(2)

- 1.5 A book is lying on a table. The reaction force to the NORMAL force acting on the book is the force exerted by the ...

- A book on the earth.
- B table on the book.
- C earth on the book.
- D book on the table.

(2)

- 1.6 Which ONE of the following has the SI unit $\text{kg}\cdot\text{m}^2\cdot\text{s}^{-3}$?

- A Work x time
- B Power x time
- C Force x velocity
- D Force x displacement

(2)

1.7 Which ONE of the following explains best why walls of dams are built THICKER at the bottom than at the top?

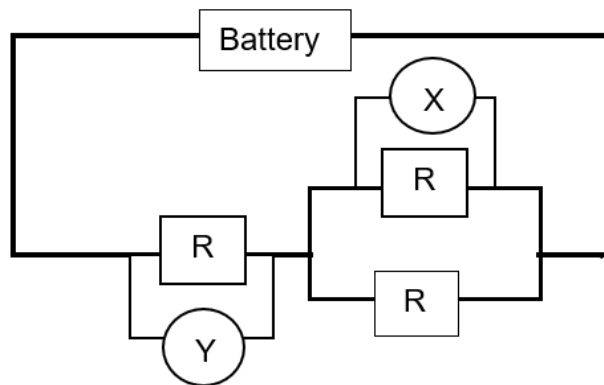
- A Liquid pressure decreases with an increase in depth.
- B Liquid pressure increases with an increase in depth.
- C Density of a liquid decreases with an increase in depth.
- D Density of a liquid increases with an increase in depth. (2)

1.8 A light ray passes from glass to air. The angle of incidence is 35° and the critical angle of glass-air surface is 42° .

Which ONE of the following is CORRECT about the path of the light ray?

The light ray will undergo ...

- A total internal reflection.
 - B refraction towards the normal.
 - C neither reflection nor refraction.
 - D refraction away from the normal. (2)
- 1.9 Resistors in the circuit diagram given below are IDENTICAL.



If voltmeter Y records a potential difference of V, then the reading on voltmeter X would be ...

- A 2 V.
- B V.
- C $\frac{1}{2}$ V.
- D 4 V. (2)

1.10 Which ONE of the following components in an electric motor enables the output current to flow in one direction?

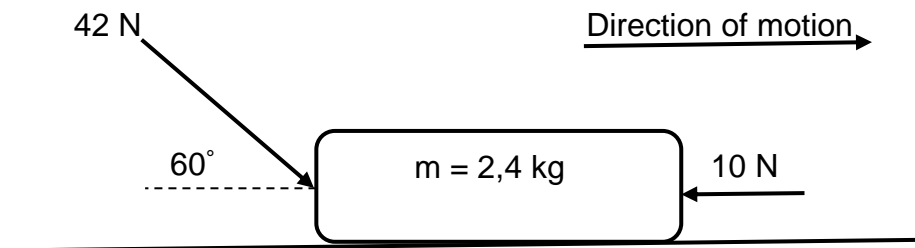
- A Magnets
- B Slip rings
- C Carbon brushes
- D Split ring commutator

(2)
[20]

QUESTION 2 (Start on a new page.)

Two forces of 42 N and 10 N are applied SIMULTANEOUSLY on a stationary block of mass 2,4 kg as shown below. The 42 N force acts at an angle of 60° to the horizontal while the 10 N is a horizontal force to the left.

The block experiences a kinetic frictional force of magnitude 6 N. The block moves to the right.



2.1 Explain the following statement:

'The stationary block has inertia.' (2)

2.2 State Newton's Second Law in words. (2)

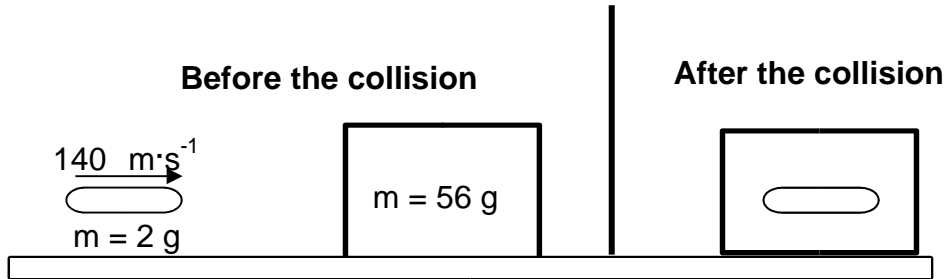
2.3 Draw a free-body diagram of all the forces acting on the block. (5)

2.4 Calculate the magnitude of the acceleration of the block. (5)

[14]

QUESTION 3 (Start on a new page.)

- 3.1 In the diagram below an air-rifle pellet of mass 2 g is fired into a stationary block of clay with a mass of 56 g. The pellet strikes the block at a speed of $140 \text{ m}\cdot\text{s}^{-1}$ to the right.



- 3.1.1 Define the term *isolated system*. (2)

Upon impact, the pellet remains inside the block, and they move together as a single unit. Ignore the effects of friction.

- 3.1.2 Will the total linear momentum of the block-bullet system change after the collision?

Write down only YES or NO. (1)

- 3.1.3 Calculate the velocity of the block-bullet system after impact. (5)

- 3.2 During a safety test, a car of mass 800 kg travelling at $20 \text{ m}\cdot\text{s}^{-1}$ east hits a brick wall and comes to a stop. To bring the car to a stop the wall exerts a force of $1,6 \times 10^3 \text{ N}$ on the car.

- 3.2.1 Define *impulse*. (2)

- 3.2.2 Calculate the time taken for the car to stop. (4)

The brick wall is covered with a pack of mattresses and the same car, still travelling at $20 \text{ m}\cdot\text{s}^{-1}$, hits the mattresses and comes to a stop.

- 3.2.3 How will the force of the mattresses on the car compare to the $1,6 \times 10^3 \text{ N}$ force exerted by the brick wall on the car?

Write only SMALLER THAN, GREATER THAN or SAME AS.

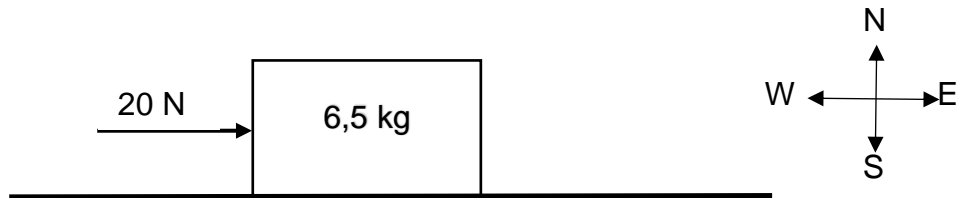
Explain the answer. (4)

[18]

QUESTION 4 (Start on a new page.)

- 4.1 A girl pushes a 6,5 kg box across a rough floor by applying a 20 N force to the east. The coefficient of kinetic friction between the box and the floor is 0,1.

The block moves a distance of 0,2 m.



- 4.1.1 Define *energy*. (2)

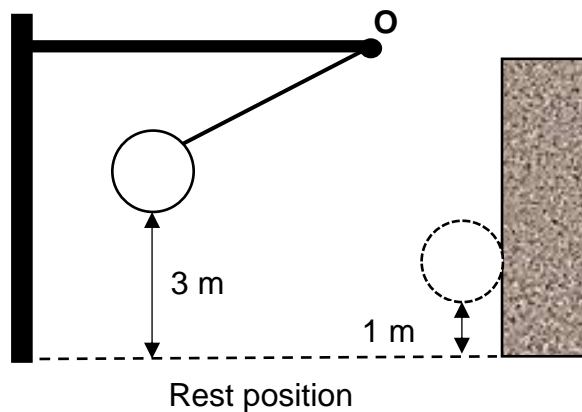
- 4.1.2 Write down the names of TWO forces that act on the block but do NO work on the box as it moves over the distance of 0,2 m. (2)

Calculate the:

- 4.1.3 Work done by the girl on the box (3)

- 4.1.4 Net work done on the box (5)

- 4.2 A construction worker demolishes a brick wall by using a spherical metal ball of mass 1 500 kg. The cable attached to the ball is fixed at point O.



The ball which is suspended from the cable, is first raised to a height of 3 m above its rest position and then released from rest to strike the wall. Ignore the effects of air friction.

- 4.2.1 State the principle of *conservation of mechanical energy* in words. (2)

- 4.2.2 Calculate the speed with which the ball strikes the wall. (Ignore the mass of the cable) (4)

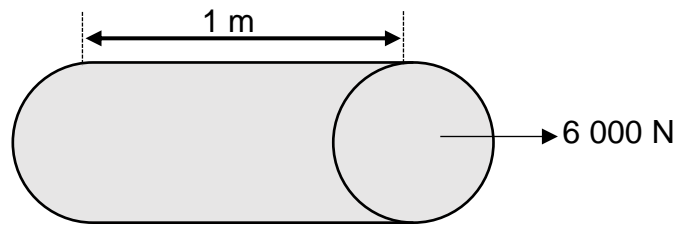
- 4.3 The engine of a motorbike exerts a force of magnitude 5 kN when the bike moves at a constant velocity of 72 km.h⁻¹.

Calculate the power delivered by the engine in the units of horsepower. (4)

[22]

QUESTION 5 (Start on a new page.)

- 5.1 A steel rod is 1 m long, with a cross sectional area of $0,5 \text{ cm}^2$ stretches by $0,24 \text{ cm}$ when a force of magnitude $6\,000 \text{ N}$ is applied as shown below.



5.1.1 State Hooke's Law in words. (2)

5.1.2 Calculate the Young's modulus of the steel rod. (7)

- 5.2 Car manufacturers use multi-grade engine oil for different working conditions. Consider the following three oils:

Oil A: 10W-30

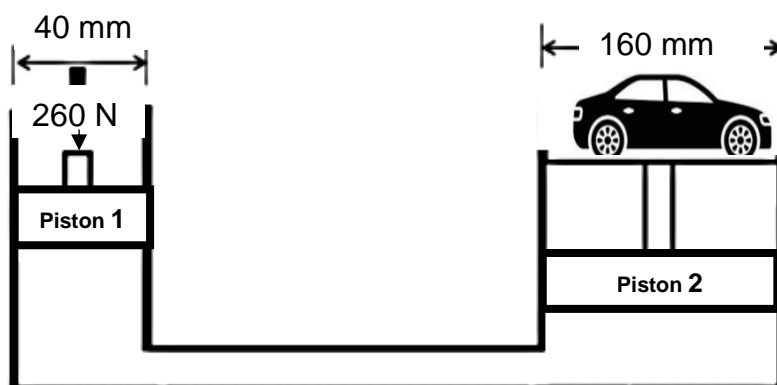
Oil B: 20W-50

Oil C: 15W-40

5.2.1 Which ONE of the oils will stay THICKER at higher temperatures? (1)

5.2.2 What does the 10 W indicate on the label for oil A? (2)

- 5.3 A motor mechanic uses a hydraulic system to lift a car as shown in the diagram below. The diameter of the small piston is 40 mm while that of the larger piston is 160 mm . A force of magnitude 260 N is applied vertically down on the smaller piston (Piston 1).



5.3.1 State Pascal's Law *in* words. (2)

5.3.2 Calculate the force exerted by the larger piston (Piston 2) on the car. (4)

5.3.3 State THREE applications of Pascal's Law in our daily lives. (3)

[21]

QUESTION 6 (Start on a new page.)

6.1 In a motor starter, parallel plate capacitor consists of two identical aluminium plates, each with an area $4 \times 10^{-4} \text{ m}^2$. The plates are separated by a distance of 0,06 m with air occupying the space between the plates.

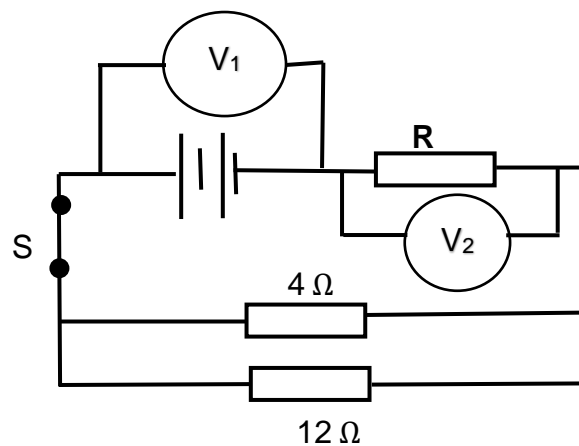
6.1.1 Define *capacitance*. (2)

6.1.2 Calculate the capacitance of the parallel plates. (3)

6.1.3 State TWO factors that affect the capacitance of a capacitor. (2)

6.2 The circuit below consist of a 6Ω and a 5Ω resistor connected in parallel and an unknown resistor **R**, in series as shown below.

The switch **S** is closed.



The total power dissipated in the parallel part of the circuit is 50 W.
The voltmeter across resistor **R** reads 8 V.

6.2.1 Define the term *power*. (2)

Calculate the:

6.2.2 Effective resistance of the parallel combination of resistors (3)

6.2.3 Resistance of resistor **R** (5)

Resistor **R** is removed and replaced with an ammeter.

6.2.4 How will this change affect the current through the 12Ω resistor?

Choose from INCREASES, DECREASES or REMAINS THE SAME.

Explain your answer. (3)

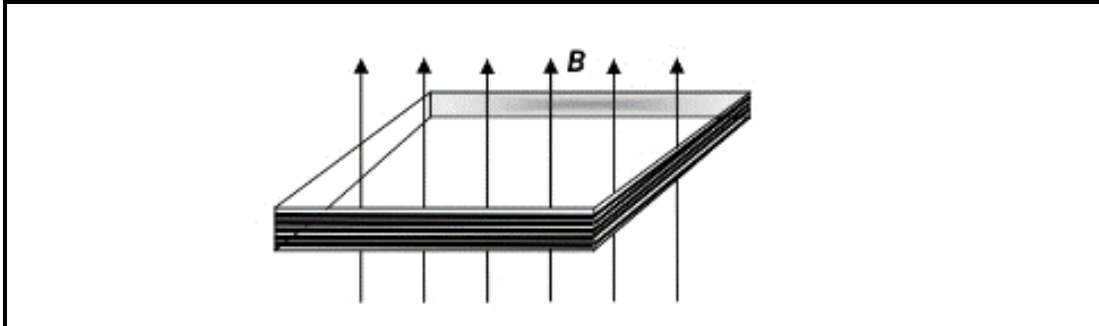
Switch **S** is now OPEN.

6.2.5 What NAME is given to the reading on V_1 when switch, **S** is open? (1)

[21]

QUESTION 7 (Start on a new page.)

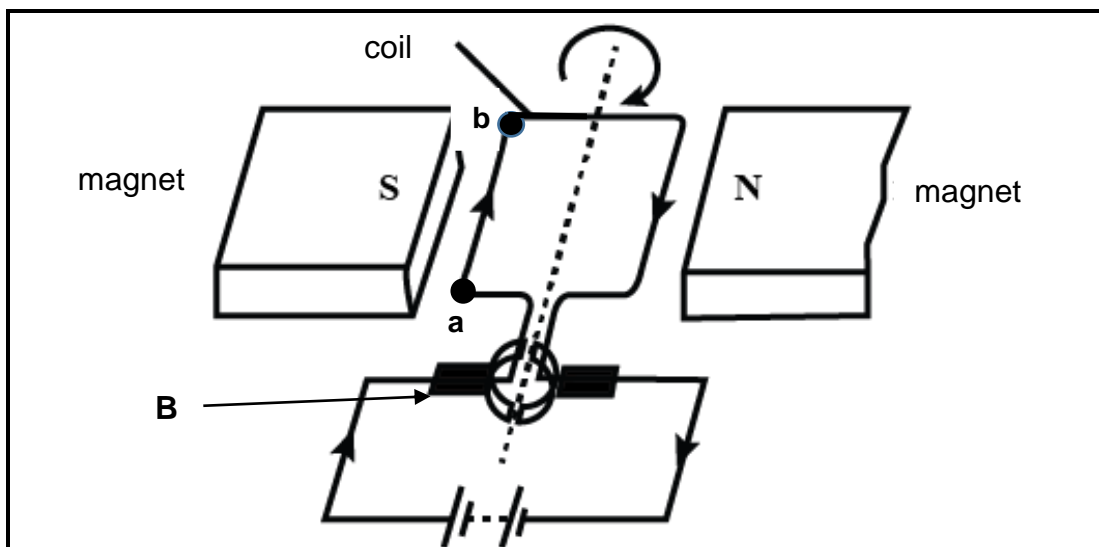
- 7.1 Consider a flat, square coil with 5 turns. Each of the coil's sides is 0,50 m in length and has magnetic field of 0,5 T passing through it. The plane of the coil is perpendicular to magnetic field.



7.1.1 Define *magnetic flux*. (2)

7.1.2 Calculate the magnitude of the induced emf if the magnetic field is increased uniformly from 0,5 T to 1 T in 10 s. (6)

- 7.2 Shown below is a simplified diagram of an electrical device.



7.2.1 Write down the NAME of this electrical device. (1)

7.2.2 State the energy conversion in the above-mentioned device. (2)

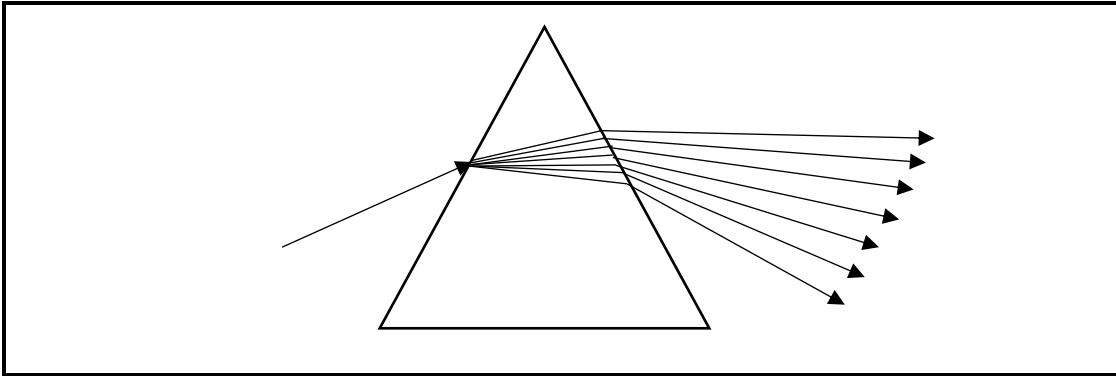
7.2.3 What is the function of component **B**. (1)

7.2.4 Draw a diagram showing the magnetic field pattern around the straight section, **ab** of the coil due to the current flowing in the coil **only**. Indicate direction of the magnetic field lines. (2)

[14]

QUESTION 8 (Start on a new page.)

8.1 The diagram below shows the dispersion of white light by a prism.



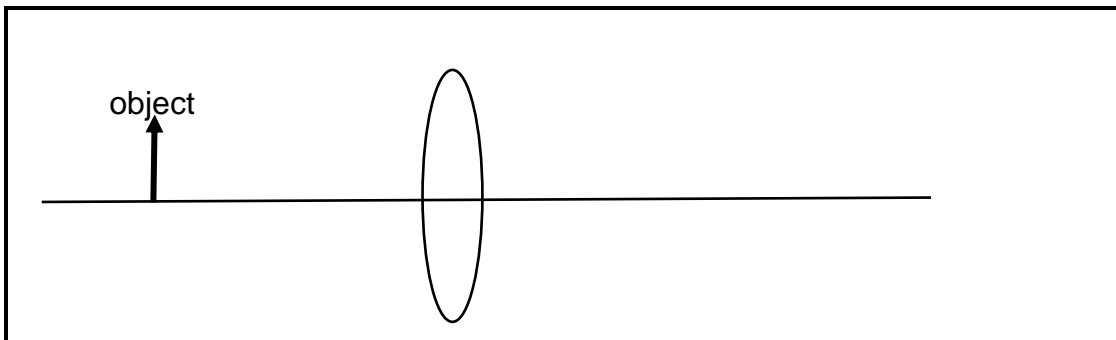
8.1.1 Define *dispersion*. (2)

8.1.2 Which colour is refracted least? (1)

8.1.3 When light travels through the prism its speed decreases but its frequency remains constant.

Explain why the frequency of light remains constant. (2)

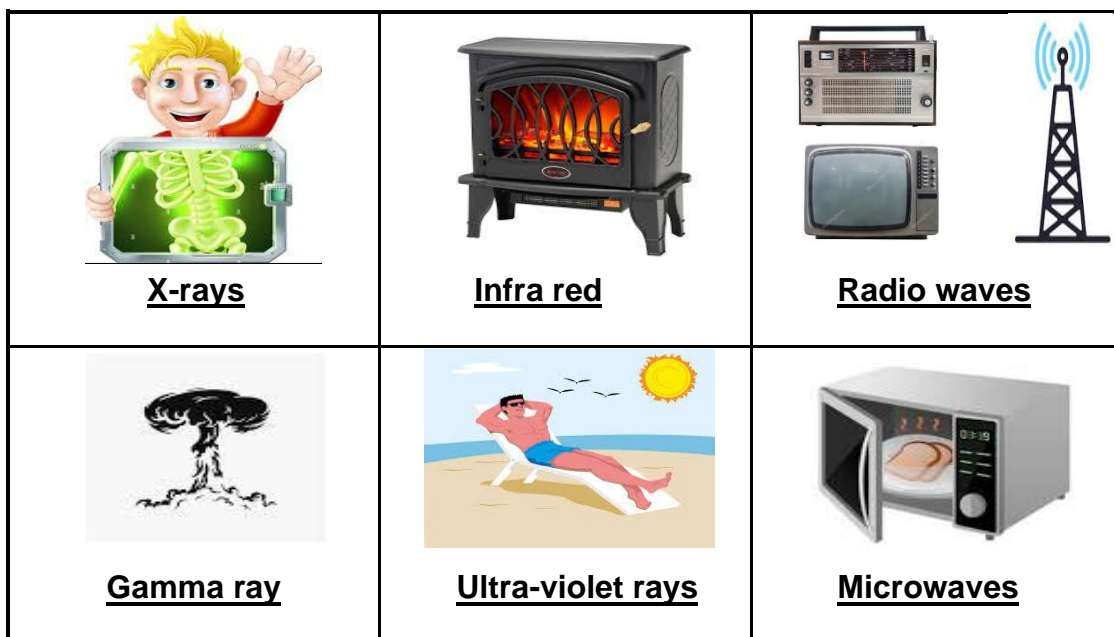
8.2 A learner places an object 40 mm tall at a distance of 25 mm in front of a lens with a focal length of 40 mm.



8.2.1 Is this a DIVERGING or CONVERGING lens? (1)

8.2.2 Draw a labelled ray diagram showing the image formed. (7)

8.3 Study the images below showing the practical applications of different types of electromagnetic radiation.



Write down the name of electromagnetic radiation that:

8.3.1 Has the longest wavelength (1)

8.3.2 Is used for security checks at airports (1)

The wavelength of the ultraviolet light ranges from 0,1 nm to 1 000 nm.

8.3.3 Define the term *photon*. (1)

8.3.4 Calculate the MINIMUM energy of a photon of ultraviolet light. (4)

[20]

TOTAL: 150

DATA FOR TECHNICAL SCIENCES GRADE 12
PAPER 1
GEGEWENS VIR TEGNIESE WETENSAPPE GRAAD 12
VRAESTEL 1

TABLE 1: PHYSICAL CONSTANTS/TABEL 1: FISIESTE KONSTANTES

NAME/NAAM	SYMBOL/SIMBOOL	VALUE/WAARDE
Acceleration due to gravity <i>Swaartekragversnelling</i>	g	9,8 m·s ⁻²
Speed of light in a vacuum <i>Spoed van lig in 'n vakuum</i>	c	3,0 x 10 ⁸ m·s ⁻¹
Planck's constant <i>Planck se konstante</i>	h	6,63 x 10 ⁻³⁴ J·s
Electron mass <i>Elektronmassa</i>	m _e	9,11 x 10 ⁻³¹ kg
Permittivity of free space <i>Permittiwiteit van vrye ruimte</i>	ε ₀	8,85 x 10 ⁻¹² F·m ⁻¹

TABLE 2: FORMULAE/TABEL 2: FORMULES**FORCE/KRAG**

$F_{\text{net}} = ma$	$p = mv$
$f_s^{\text{max}} = \mu_s N$	$f_k = \mu_k N$
$F_{\text{net}} \Delta t = \Delta p$ $\Delta p = mv_f - mv_i$	$F_g = mg$
$MA = \frac{L}{E} = \frac{e}{l}$	

WORK, ENERGY AND POWER/ARBEID, ENERGIE EN DRYWING

$W = F\Delta x \cos\theta$	$U = mgh$ or/of $E_p = mgh$
$K = \frac{1}{2}mv^2$ or/of $E_k = \frac{1}{2}mv^2$	$W_{\text{net}} = F_{\text{net}}\Delta x \cos\theta$ $\Delta K = K_f - K_i$ or/of $\Delta E_k = E_{kf} - E_{ki}$
$P_{\text{ave}} = FV_{\text{ave}}$ / $P_{\text{gemid}} = FV_{\text{gemid}}$	$P = \frac{W}{\Delta t}$
	$M_E = E_k + E_p$

ELASTICITY, VISCOSITY AND HYDRAULICS/ELASTISITEIT, VISKOSITEIT EN HIDROULIKA

$\sigma = \frac{F}{A}$	$\varepsilon = \frac{\Delta l}{L}$
$\frac{\sigma}{\varepsilon} = K$	$\frac{F_1}{A_1} = \frac{F_2}{A_2}$
$P = \frac{F}{A}$	$P = \rho gh$

ELECTROSTATICS / ELEKTROSTATIKA

$C = \frac{Q}{V}$	$C = \frac{\varepsilon_0 A}{d}$
-------------------	---------------------------------

CURRENT ELECTRICITY/STROOMELEKTRISITEIT

$R = \frac{V}{I}$	$\text{emf/emk } (\mathcal{E}) = I(R + r)$
$R_s = R_1 + R_2 + \dots$ $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$	$q = I\Delta t$
$W = VQ$ $W = VI\Delta t$ $W = I^2R\Delta t$ $W = \frac{V^2\Delta t}{R}$	$P = \frac{W}{\Delta t}$ $P = VI$ $P = I^2R$ $P = \frac{V^2}{R}$

ELECTROMAGNETISM/ELEKTROMAGNETISME

$\Delta\Phi = BA$	$\mathcal{E} = -N \frac{\Delta\Phi}{\Delta t}$
$\frac{V_s}{V_p} = \frac{N_s}{N_p}$	

WAVES, SOUND AND LIGHT / GOLWE, KLANK EN LIG

$v = f\lambda$	$T = \frac{1}{f}$
$E = hf$ or $E = h\frac{c}{\lambda}$	