NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2008

PHYSICAL SCIENCES: PAPER I

Time: 3 hours 150 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of:
   - a question paper of 17 pages
   - a data and formula booklet of 3 pages (i – iii)

   Please make sure that your question paper is complete.

2. Remove the pages of data and formulae from the middle of this question paper.

3. Use the data and formulae whenever necessary.

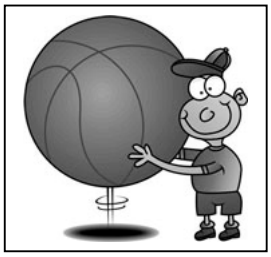
4. Read the questions carefully.

5. In Question 1 answer 1.1, 1.2 and **EITHER** 1.3 **OR** 1.4.
   In Question 4 answer **EITHER** 4.1 **OR** 4.2.

6. It is in your own interest to write legibly and to set your work out neatly.

QUESTION 1 PLAY BALL

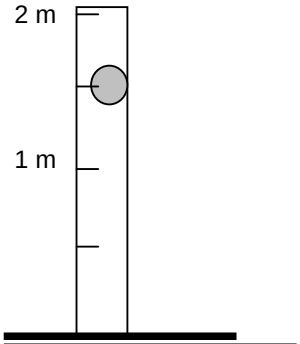
Start this question on a new page



1.1 Neil says that a bouncing ball will have inelastic collisions with the floor, but Susan disagrees with him. They set up an experiment to test Neil's statement.

A ball (mass 250 g) is dropped from a fixed height of 2 m. The time taken from the moment it leaves Susan's hand until it touches the floor is timed by Neil with a stopwatch. They record the height reached after the bounce by taking photographs of the ball bouncing back to maximum height in front of a 2 m ruler.

They repeat these measurements three times and record the following results for the time taken to reach the floor as 0,61s, 0,65s and 0,64s respectively, and for the corresponding maximum height of the bounce as 1,54 m, 1,60 m and 1,58 m respectively.



1.1.1 Draw up a table of the results of this experiment and calculate the average values of time taken and maximum height reached. Include these average values in the table. Make sure that your columns have appropriate headings and SI units. (4)

1.1.2 What is the magnitude of the acceleration of the ball while it falls to the floor? Ignore the effects of air resistance. (1)

1.1.3 Use the values from the table to calculate the magnitude of the velocity of the ball when it reaches the floor. (3)

1.1.4 Use results from the table to calculate the magnitude of the velocity when it leaves the floor. (3)

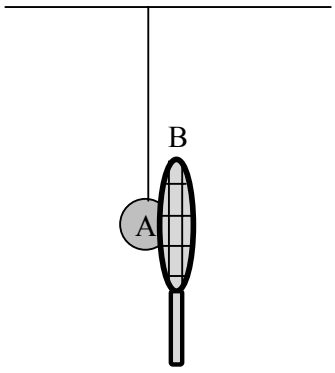
1.1.5 Make use of your answers in 1.1.3 and 1.1.4 to prove that Neil's statement is correct. (3)

1.1.6 Explain, in terms of energy transfers, why a bouncing ball has inelastic collisions with the floor. (2)

1.1.7 Draw a **position-time graph** of the motion of the ball from the moment it leaves Susan's hand until it hits the floor a second time. Use a ruler to draw your axes. Take the floor as your frame of reference and choose the 'upwards' direction as positive. Clearly show all known values for position and time on the graph. (4)

[20]

1.2 Ball A (mass 0,25 kg) hangs from a long, light, inextensible string. Neil strikes the ball through its centre of gravity to the left with a bat B. Bat B travels at a velocity of 2 $m \cdot s^{-1}$ to the left when it strikes the ball.



After the collision, bat B (mass 2,5 kg) travels left (in the same direction) at 1,6 $m \cdot s^{-1}$.

Ignore any effects of air resistance.

1.2.1 State fully, in words, the Law which can be used to determine the velocity of ball A immediately after the collision. (2)

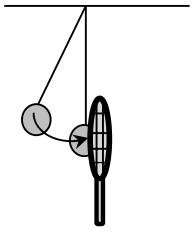
1.2.2 Calculate the speed of ball A immediately after the collision. (4)

1.2.3 State fully in words the Law which can be used to determine the maximum gain in height of ball A after the collision. (2)

1.2.4 Calculate the maximum gain in height of ball A after the collision. (3)

1.2.5 How much work does Neil do on the ball for it to gain this height? (1)

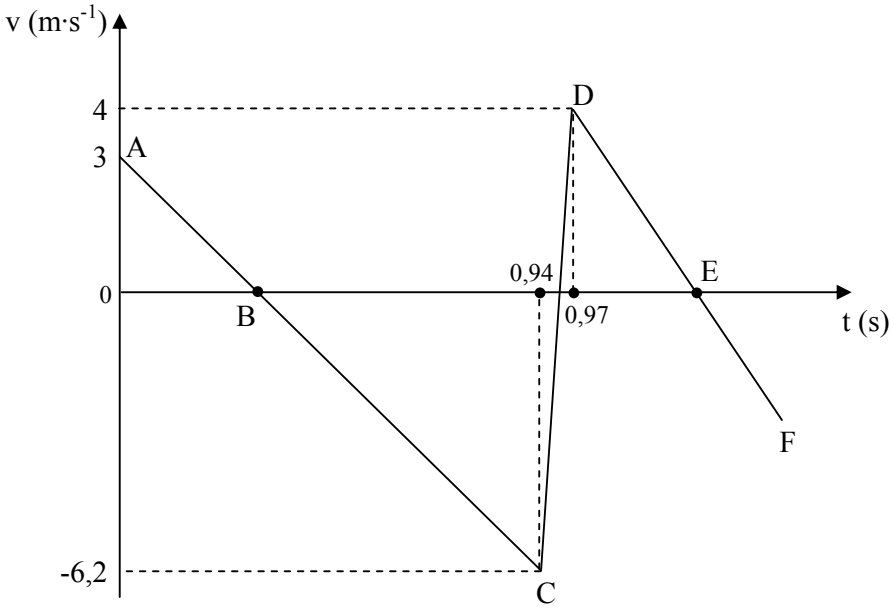
1.2.6 Would Neil do the same amount of work on the ball for it to reach the same maximum height when he hits it to the left again as it returns to the bottom of its swing? Justify your answer.



(3)
[15]

ANSWER QUESTION 1.3 OR QUESTION 1.4

1.3 The following diagram shows the velocity-time graph for the same ball (mass 0,25 kg) bouncing during **another** experiment.



1.3.1 Describe the motion of the ball from A to B. (1)

1.3.2 Describe the motion of the ball from B to C. (1)

1.3.3 At which point on the graph does the ball reach maximum height after the first bounce? (1)

1.3.4 For how long (in seconds) is the ball in contact with the floor? (1)

1.3.5 Define 'impulse'. (2)

1.3.6 Calculate the magnitude of the net force on the ball while it is in contact with the floor during the first bounce. (3)

1.3.7 In which direction does this net force act on the ball? (1)

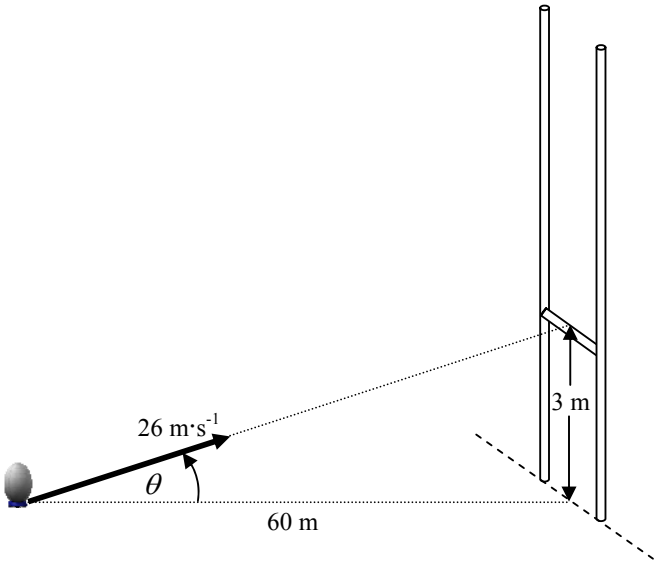
[10]

OPTIONAL QUESTION

ONLY ANSWER QUESTION 1.4 IF YOU LEFT OUT QUESTION 1.3

QUESTION 1.4 MOTION IN 2-DIMENSIONS

1.4 Percy has to kick the ball straight over the crossbar of the rugby posts in order to gain 3 points for his rugby team.



The crossbar of the rugby posts is 3 m high. The ball is 60 m in front of the posts.

Percy kicks the ball with an initial velocity of 26 $m \cdot s^{-1}$ at an angle, $\theta = 35^{\circ}$ to the horizontal.

Ignore any effects of air resistance.

1.4.1 Determine the maximum height gained by the rugby ball. (3)

1.4.2 Determine the maximum range of the rugby ball. (5)

1.4.3 Explain whether Percy manages to score the 3 points for his team. (2)
[10]

45 marks

QUESTION 2 WAVES, SOUND AND LIGHT

Start this question on a new page

2.1 Colours

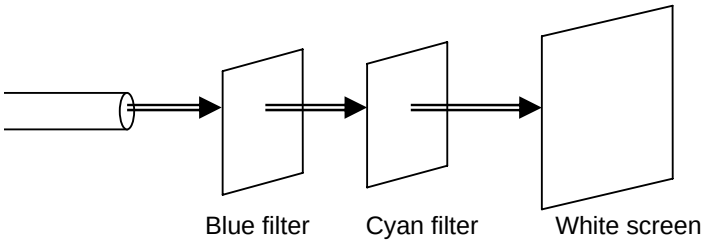
2.1.1 Lesego is wearing a yellow jacket with black stripes.

(a) Name the three primary colours of light. (1)

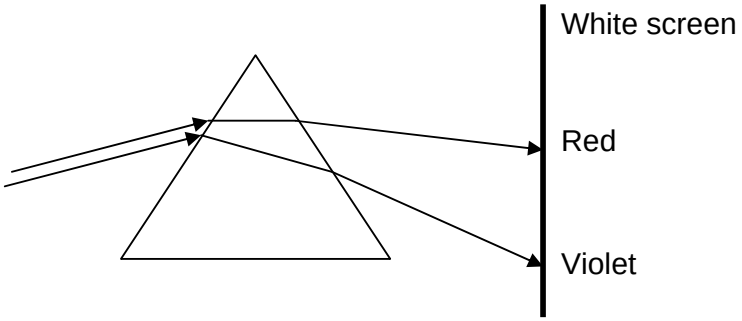
(b) When white light shines on the yellow parts of the jacket, what primary colour(s) of light is/ are reflected? (2)

(c) Explain what happens when white light shines on the black stripes. (2)

2.1.2 A narrow beam of white light shines through a blue filter, and then through a cyan filter. Explain what will be seen on the white screen. (3)



2.1.3 White light can be separated into light of different colours by passing a narrow beam of white light through a glass prism, as shown in the diagram below.

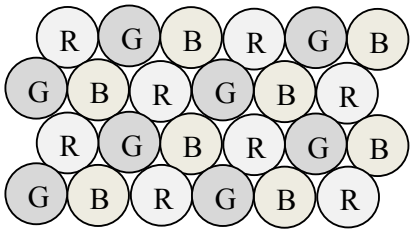


(a) Name **the phenomenon that causes** white light to separate into the colours of the rainbow when it passes through the prism. (1)

(b) Explain how this happens when white light passes through the prism. (2)

2.1.4 A colour TV screen is covered with red, green and blue phosphor dots which are arranged in groups close to each other.

Three electron beams move at the same time across the TV screen. One of the electron beams fires electrons at the red dots; the second electron beam fires electrons at the green dots and the third one fires electrons at the blue dots.



When an electron beam strikes a red phosphor dot it glows red; similarly the green and blue phosphor dots glow green and blue respectively when an electron beam strikes them. These electron beams are therefore called the red, blue and green beams.

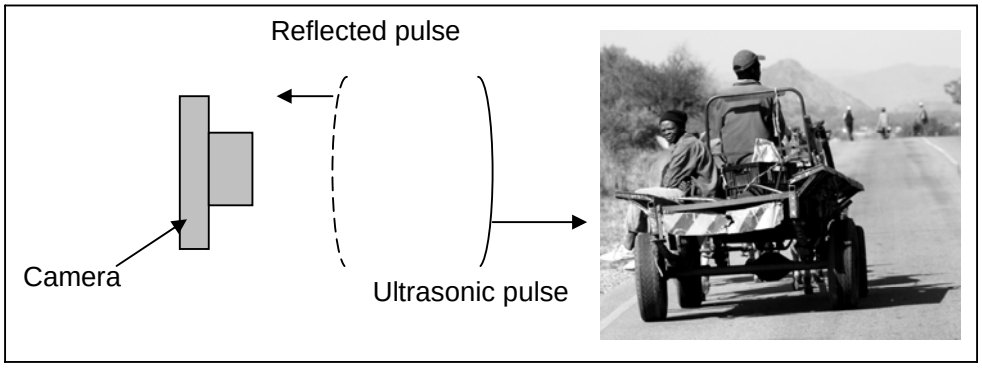
To stop an electron beam from striking a dot there is a thin metal screen called a shadow mask. This mask covers the blue, green and/ or red dots or it can open some or all of them to be exposed to the electrons.

Explain how the three electron beams succeed in making purple. (4)

[15]

2.2 The physics of an auto-focusing camera

Some cameras have a mechanism that automatically focuses the camera with the aid of sound waves. The diagram demonstrates the central idea of this feature.



When you push the auto-focus button on the camera, it sends out a pulse of ultrasonic sound that travels to the object being photographed. Like an echo, the pulse reflects off the subject and returns to the camera.
By measuring the time it takes to make the round-trip, and using 340 $m.s^{-1}$ for the speed of sound, the camera calculates the distance to the object and sets the lens to its proper focus.

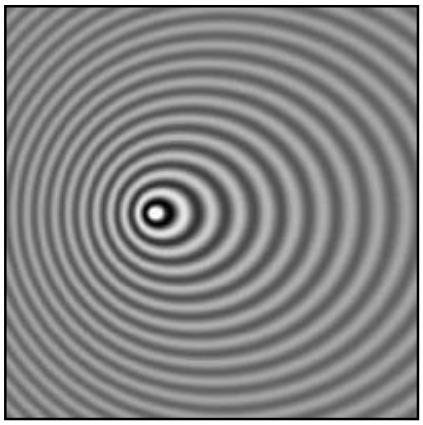
[Physics: *Cutnell/Johnson* 3rd edition]

2.2.1 Explain how to calculate the distance to the object from the data which is available to the camera. (3)

2.2.2 This automatic focusing mechanism is not always accurate. Give two possible scientific reasons for this. (2)
[5]

2.3 The Doppler Effect

The photograph alongside shows a moving source of sound waves.



This phenomenon was named the Doppler Effect after the German scientist, Christian Doppler.

2.3.1 In which direction is the source moving: to the left, or to the right? (1)

2.3.2 What happens to the observed wavelength of the waves on the left of the source? (1)

[<http://en.wikipedia.org/wiki/Doppler_effect>]

2.3.3 The sound source is moving towards you, a stationary observer. How will **the pitch of the sound you hear** differ from its pitch when the source is stationary? (1)

The applications of this effect are numerous. In the Navy this effect is used by submarines to detect the presence and speed of ships.

A submarine is lying motionless under water in the sea. It detects a sound coming from a moving ship. The frequency detected is 1,003 times greater than the actual frequency of the sound emitted by the ship.

The speed of sound in salt water is 1 470 $m.s^{-1}$.

2.3.4 Why does sound travel so much faster in water than it does in air? (1)

2.3.5 The actual frequency of the sound that the ship emits is f_s. Write an equation for the frequency detected by the submarine, f_o, in terms of f_s. (2)

2.3.6 Calculate the velocity of the ship. (4)

2.3.7 Give **one other** application of the Doppler Effect which has a profound effect on the quality of human life (or society). Explain how it works, and explain why you consider its effect to be so important. (5)

[15]

35 marks

QUESTION 3 ELECTRICAL ENERGY

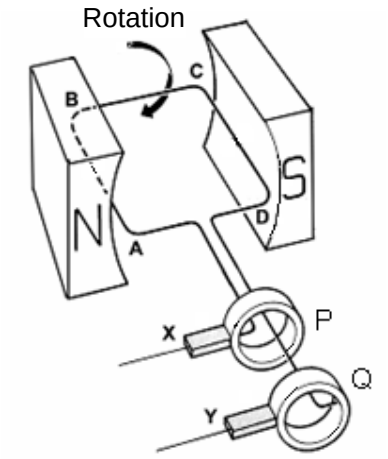
Start this question on a new page

We will remember 2008 as the year of darkness, or if you prefer, the start of the big power crisis. Load shedding was a frequent occurrence, and the sales of generators went sky high. Every day brought a joke or two on load shedding and ESKOM, until the daily papers begged people to stop targeting ESKOM. Perhaps one of the best cartoons of the year was the following:

This cartoon was sponsored by ESKOM

[Source: *The Star*]

A simple generator consists of a coil turning in a magnetic field. The magnetic field is produced by permanent magnets. Look at the diagram.



Answer the following questions:

3.1 When a conductor moves in a magnetic field, an emf is induced in the conductor. What is this phenomenon called? (1)

3.2 What energy transfers take place **in the generator**? (1)

3.3 Name components P and Q. (1)

3.4 What is the function of components P and Q? (1)

3.5 Name components X and Y. (1)

3.6 What is the function of components X and Y? (1)

The following diagrams show the rotation of the coil in the magnetic field.

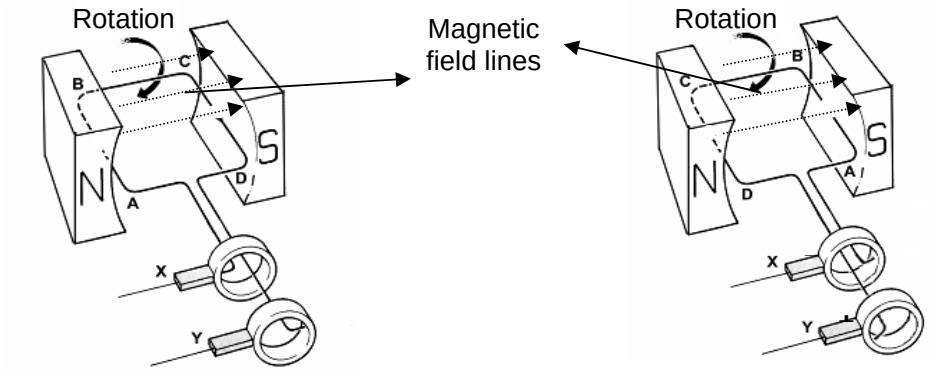


Diagram 1
Start of cycle

Diagram 2
½ cycle

The coil is turned mechanically in a clockwise direction, i.e. AB starts moving upwards from the horizontal and CD starts moving downwards (as shown in Diagram 1).

After a ¼ cycle the coil has turned through 90°. AB will now be at the top and CD at the bottom (the coil is vertical).

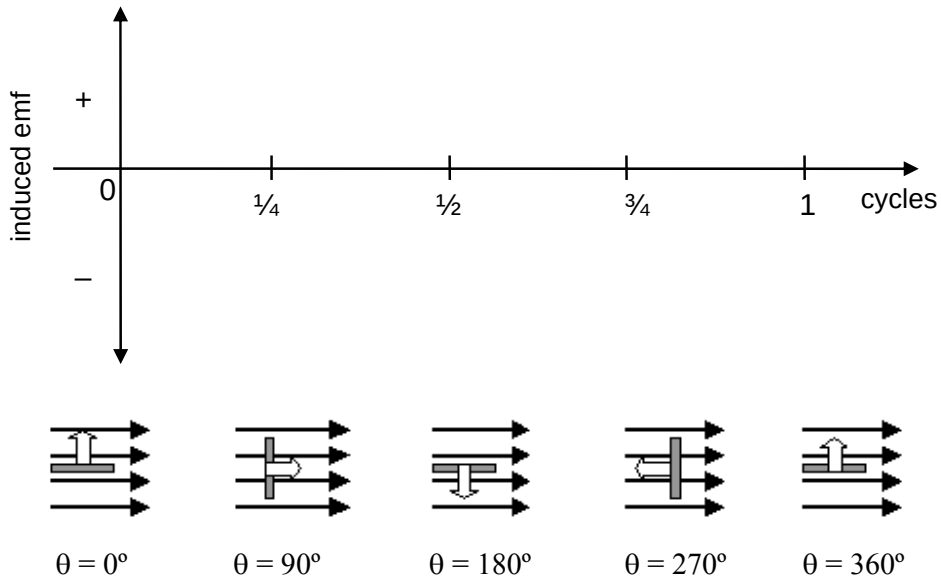
After ½ cycle, AB will now be on the right hand side and CD on the left hand side (the coil is horizontal), as shown in Diagram 2.

3.7 The following table shows the position and motion for one complete cycle of the coil, starting with AB on the left hand side, moving up. Write only the number of the question and the missing value to complete the table.

Position of coil	**Motion of part AB of coil**	**Magnitude of current (max or zero)**	**Direction of current (ABCD or DCBA)**
horizontal	moving up, cutting field lines	3.7.1	3.7.2
vertical	parallel to field lines, moving to the right	3.7.3	
horizontal	moving down, cutting field lines	3.7.4	3.7.5
vertical	parallel to field lines, moving to the left		3.7.6
horizontal	moving up, cutting field lines	3.7.7	

(6)

3.8 Redraw the following set of axes in your answer book.



θ = 0º θ = 90º θ = 180º θ = 270º θ = 360º

The group of arrows indicates the direction of the magnetic field and the block arrow indicates the direction of motion of **AB** of the coil. The angle θ indicates the angle through which section **AB** has turned.

3.8.1 Draw the graph of the induced emf for one complete cycle of **section AB** of the coil, when **AB** starts from the horizontal position. (4)

3.8.2 **On the same set of axes** (as used in 3.8.1) draw the graph of the induced emf in section **AB** of the coil when the coil is rotated at half its original speed. (4)

[20]

3.9 **Load shedding**

Load shedding was introduced by ESKOM in order to provide key businesses and public services, e.g. mines and hospitals, with electrical energy when the demand for energy exceeded ESKOM's capacity. All South Africans have been asked to use electrical energy more efficiently, or to make use of other sources of energy.

3.9.1 Give **two practical ways** in which you and your family can use electrical energy from ESKOM more efficiently. (2)

Here are some facts for you to consider when answering 3.9.2 – 3.9.5

- A 25 ℓ hot water geyser supplies sufficient hot water for either 2 baths, 1 bath and 1 shower, or 3 showers only.
- A 25 ℓ electrical water-heating geyser takes an average of 30 minutes to raise the temperature to 55º C with an average power input of 2 kW at a cost of R 0,25 per kW.h. It costs about R 2 000 per year to operate the geyser for a family of 4 people.
- A 25 ℓ solar water-heating geyser takes an average of 6 h of mild sunshine to raise the temperature to 55º C. It costs R15 000 to install a solar water-heating geyser, but only R5 000 to install an electrical geyser of similar capacity.

3.9.2 How many years will it take for your solar hot water supply to be 'free'? (1)

3.9.3 Give **two advantages** of an electrical geyser. (2)

3.9.4 Give **two disadvantages** of a solar water-heating geyser. (2)

3.9.5 Considering **ALL** the information given to you in this question, choose which geyser you would install in your newly built house, and motivate your choice with **two** reasons. (3)

[10]

30 marks

QUESTION 4

Start this question on a new page

ANSWER QUESTION 4.1 OR QUESTION 4.2

4.1 LEDS

'LED's are real unsung heroes in the electronics world. They do dozens of different jobs and are found in all kinds of devices. Basically LED's are just tiny light sources that fit easily into an electric circuit.
LED's have several advantages over conventional incandescent lamps. For one thing, they have no filament that will burn out, so they last much longer. Also their small plastic bulb allows them to fit more easily into modern electronic circuits.'

The above was adapted from an article written by Tom Harris found on the Internet.

4.1.1 What does LED stand for? (1)

4.1.2 What is the function of a LED in an electronic circuit? (1)

4.1.3 Draw the circuit diagram symbol for a LED. Clearly show the anode and the cathode. (2)

4.1.4 Explain how an LED works in terms of the type of materials from which it is made, and how it is constructed. (You can make use of a suitable diagram to aid your explanation.) (4)

4.1.5 Give **two more advantages** of LED's to those mentioned in the above article written by Tom Harris. (2)
[10]

ANSWER QUESTION 4.2 IF YOU DID NOT ANSWER QUESTION 4.1.

4.2 LASERS

4.2.1 What do the letters of the name 'LASER' represent? (2)

4.2.2 Why is a laser beam always monochromatic? (1)

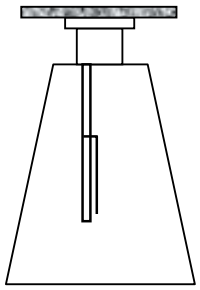
4.2.3 Briefly explain how a laser works. (You can make use of a diagram to aid your explanation.) (4)

4.2.4 Laser technology has had a profound effect on the quality of human life. Give **one example** of the use of lasers, and explain how this technology has had such an effect **on the quality** of our lives. (3)
[10]

10 marks

QUESTION 5 EXPERIMENTING WITH LIGHT SHINING ON METALS

5.1 Peter and Avni want to investigate whether electrons are emitted by a metal as a result of light shining on it. They find some sheets of aluminium, copper and iron in their school's laboratory. They also find a piece of apparatus which looks like that which is shown in the diagram below.



5.1.1 Name this piece of apparatus. (1)

5.1.2 Name the 'effect' that they are discussing. (1)

Peter and Anvi make a list of threshold frequencies for each of these metals.

Metal	Threshold frequency (Hz)
aluminum	$9{,}85 \times 10^{14}$
copper	$1{,}13 \times 10^{15}$
iron	$1{,}09 \times 10^{15}$

5.1.3 Explain what **the threshold frequency** of a metal is. (2)

In the laboratory they find three light sources with the same intensity which are labelled as being the following colours and frequencies:

Light	Frequency
ultra violet	$1{,}25 \times 10^{15}$ Hz
blue	$6{,}67 \times 10^{14}$ Hz
infra red	$1{,}22 \times 10^{13}$ Hz

They put the aluminium sheet on the metal cap of the instrument and give the instrument with the sheet, a negative charge. (Diagram 1).

Then they shine the ultra violet light on the aluminium sheet and observe that the gold leaf diverges further. (Diagram 2).

They then discharge the instrument and switch off the light source.

Taking each of the different colours of light in turn, they repeat this procedure and record their results for the aluminium sheet.

Then they repeat the whole procedure using the copper sheet and the three light sources and then the iron sheet with the same sources. Their collect their results in a table as shown below.

Diagram 1

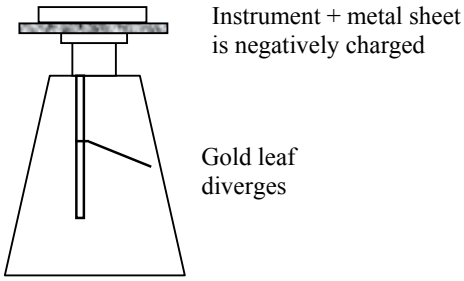
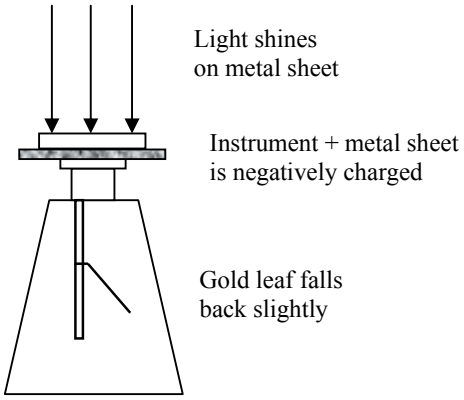


Diagram 2



	aluminium	copper	iron
ultra violet	a	b	c
blue	d	e	f
infra red	g	h	i

5.1.4 Use the letters in the table and list **only** those experiments where you think that Peter and Avni **will observe a change in the position of the gold leaf**. Give the letter and state what would be observed. (4)

5.1.5 Give a reason for the observation in experiment **a.** (2)

5.1.6 Give a reason for the observation in experiment **h**. (1)

5.1.7 Explain whether it would make any difference to the observations to experiment **a** if they used an ultra violet light source of a higher intensity. (1)

5.1.8 Explain whether they would observe anything different in experiment **a** if light of a higher frequency but with the same intensity was used. (1)

5.1.9 Peter and Avni want to report back in general on what they have learnt from these experiments.
Make use of bullets and **identify at least four general observations** on the results of these experiments. (4)

[17]

5.2 Here is a table of the frequencies and wavelengths of various types of electromagnetic radiation:

	wavelength (m)	**frequency (Hz)**
γ-rays	10^{-12} and less	10^{20} and more
X-rays	$10^{-12} – 10^{-9}$	$10^{17} – 10^{20}$
ultra violet light	$10^{-9} – 10^{-7}$	$10^{15} – 10^{17}$
visible light	$10^{-7} – 10^{-6}$	$10^{14} – 10^{15}$
infra red light	$10^{-6} – 10^{-3}$	$10^{11} – 10^{14}$
micro waves	$10^{-3} – 1$	$10^{8} – 10^{11}$
radio waves	$1 – 10^{4}$	$10^{5} – 10^{8}$

5.2.1 State the relationship between wavelength and frequency of electromagnetic radiation **in words**. (2)

5.2.2 Calculate the wavelength of the blue light Peter and Avni used in their experiment. (2)

5.2.3 Where will the following electromagnetic radiations be used in day to day life?

(a) radiation with a frequency of $2{,}4 \times 10^{18}$ Hz (1)

(b) radiation with a wavelength of 1 378 m (1)

(c) radiation with a wavelength of $4{,}3 \times 10^{-5}$ m (1)

5.2.4

(a) Give the equation relating the energy and frequency for all types of electromagnetic radiation. (1)

(b) Use the relationship written down in (a) to explain why radiation with a frequency of $3{,}12 \times 10^{22}$ Hz can be life threatening. (2)

(c) Give the **name** of this radiation. (1)

(d) Mention **where and when** (no need for a date) this radiation was used to annihilate millions of people, forever changing history. (2)

[13]

30 marks

Total: 150 marks