NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2022

TECHNICAL SCIENCES: PAPER I

Time: 3 hours 150 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 12 pages and a Data Sheet of 2 pages (i–ii). Please check that your question paper is complete.
2. This paper consists of TEN questions. Answer ALL the questions in the Answer Book.
3. Please start each question on a new page of your Answer Book.
4. Number your answers exactly as the questions are numbered.
5. Leave ONE line open between sub-questions, for example between QUESTION 2.1 and QUESTION 2.2.
6. You may use a non-programmable calculator.
7. You may use appropriate mathematical instruments.
8. You are advised to use the attached DATA SHEET.
9. Show ALL formulae and substitutions in ALL calculations.
10. Round off your final numerical answers to a MINIMUM of TWO decimal places.
11. Give brief motivations, discussions, etc. where required.
12. Read the questions carefully.
13. Do not write in the margin.
14. It is in your own interest to write legibly and to present your work neatly.

QUESTION 1 MULTIPLE-CHOICE QUESTIONS

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

1.1 The tendency of an object to remain at rest or to continue in its uniform motion in a straight line is known as …

A speed.
B acceleration.
C inertia.
D mass. (2)

1.2 Net force is a measure of the …

A rate of change in energy.
B change in energy.
C rate of change in momentum.
D change in momentum. (2)

1.3 A measure of resistance to flow which arises due to the internal friction between layers of fluid is known as …

A fluid pressure.
B viscosity.
C vapour pressure.
D kinetic friction. (2)

1.4 What happens when the stress applied to an object is increased beyond the maximum value and is removed after some time?

A The object will regain its original shape and size.
B The object will oppose the stress.
C The object becomes hot.
D The object cannot return to its original shape and size. (2)

1.5 The unit of strain is …

A newton.
B joule.
C pascal.
D no unit. (2)

1.6 Sun rays fall on a glass prism. Which of the following rays will be refracted the least?

A Blue
B Violet
C Red
D Yellow (2)

1.7 When an object is placed beyond **2F** in front of a lens that is prescribed for a person that is near sighted, the image that will form has the following properties:

A smaller, upright, virtual and image forms between F and the lens.
B smaller, inverted, real and image forms between F and the lens.
C enlarged, upright, virtual and image forms between F and 2F.
D enlarged, inverted, real and image forms between F and 2F. (2)

1.8 To get 2 Ω resistance using only 6 Ω resistors, the number of 6 Ω resistors required is …

A 2.
B 3.
C 4.
D 6. (2)

1.9 Two devices are connected between two points A and B in parallel. The physical quantity that will remain the same between the two points is …

A current.
B voltage.
C resistance.
D energy. (2)

1.10 To increase the capacitance of a parallel-plate capacitor, you can:

A increase the area of the plates.
B increase the distance between the plates.
C replace the dielectric with a vacuum.
D add a resistor in series with the capacitor. (2)

[20]

QUESTION 2 (Start on a new page)

Two blocks, **P** and **Q**, are resting on a rough horizontal surface. The blocks have masses of 2 kg and 5 kg respectively. A constant force **F** is applied to the 5 kg block at an angle of 30° to the horizontal, as shown below.

The two blocks now move to the **LEFT**. Block **P** and **Q** experience constant frictional forces of 2 N and 6 N respectively.

2.1 Draw a labelled free body diagram for the 5 kg block. Indicate all the forces acting on the block. (5)

2.2 Calculate the horizontal component of the force **F**. (2)

2.3 Define *frictional force.* (2)

2.4 Calculate the coefficient of kinetic friction (μ_k) between the surface and block **Q**. (5)

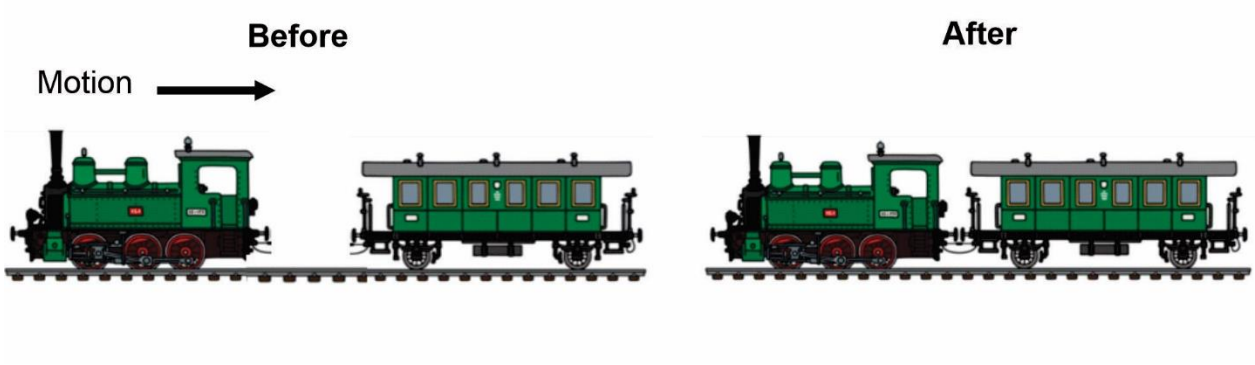
2.5 Calculate the magnitude of the force that block **P** exerts on block **Q**. (6)

2.6 State in words the law of motion that you used to calculate the force that block **P** exerted on block **Q** in **Question 2.5**. (2)

[22]

QUESTION 3 (Start on a new page)

At a train station a train carriage must be hitched to a locomotive. The locomotive and the train carriage have masses of 30 tons and 15 tons respectively. The train carriage is at rest.



The locomotive is moving at a speed of 7,2 km·h^{-1} when it collides with the train carriage to hitch it to the train carriage.

3.1 Convert the locomotive's speed to m·s^{-1}. (2)

3.2 State the principle of the conservation of linear momentum in words. (2)

3.3 Calculate the magnitude of the velocity of the locomotive after the collision. (4)

3.4 Define, in words, the term *impulse.* (2)

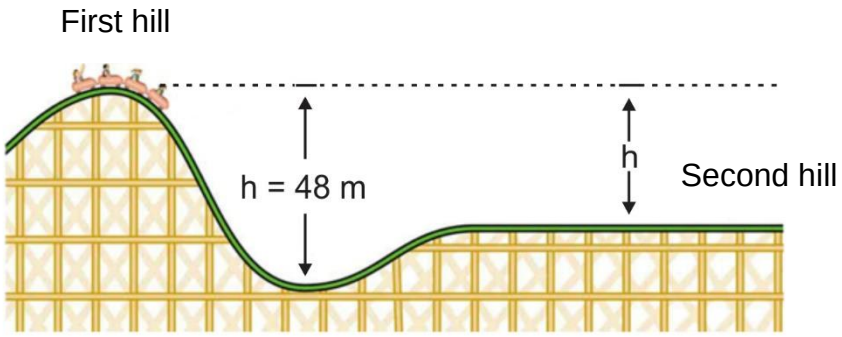
3.5 If the collision lasts 0,2 seconds, calculate the force the locomotive exerts on the train carriage during the collision. (4)

3.6 What is the magnitude of the force that the train carriage exerts on the locomotive? Give a reason for your answer. (2)

[16]

QUESTION 4 (Start on a new page)

A team of designers are designing a roller coaster. The roller coaster with a mass of 800 kg is designed that it will have a velocity of 2 $m \cdot s^{-1}$ at the top of the first hill. The height of the first hill is 48 m.



The designers of the ride want the roller coaster to have a speed of 14 $m \cdot s^{-1}$ at the top of the second hill. Ignore all the effects of friction.

4.1 State the *law of conservation of mechanical energy*. (2)

4.2 Calculate the difference in height between the first and second hill. (5)

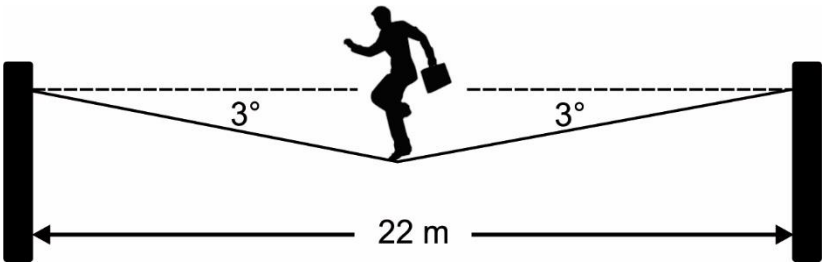
An electrical motor exerts a constant force of 4,2 kN to pull the rollercoaster up the first hill at a constant speed of 2 $m \cdot s^{-1}$.

4.3 Calculate the power of the electrical motor in horsepower. (4)

[11]

QUESTION 5 (Start on a new page)

A tight rope walker, with a mass of 55 kg, stands still in the centre of a tight rope. As shown in the diagram below. The rope has a diameter of 3 cm.
The rope elongates as a result of the weight of the man.
The elongated rope makes an angle of 3° with the horizontal.



5.1 Calculate the change in length of the rope. (3)

The rope experiences a force of 610 N.

5.2 Calculate the stress experienced by the rope. (4)

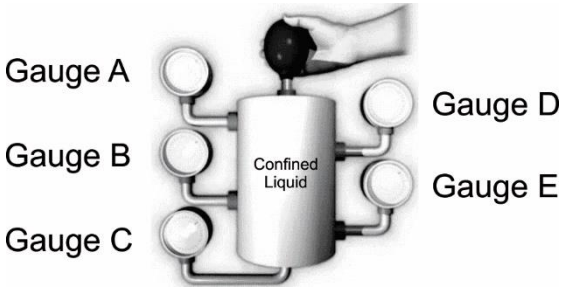
5.3 Calculate the strain of the rope. (3)

5.4 Define *Hooke's law*. (2)

5.5 Calculate the elasticity modulus for this rope. (3)
[15]

QUESTION 6 (Start on a new page)

The apparatus below is used to explain pressure in a confined liquid.
The apparatus has 5 pressure gauges. The pressure is increased by pressing the hand pump at the top.

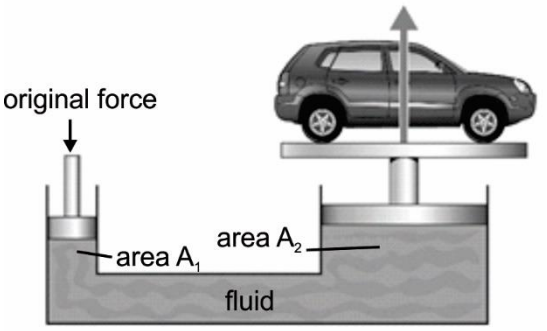


6.1 What will you observe on the gauges when the pressure is increased? Choose from **A** or **B**.

A all the pressure gauges give the same reading.
B all the pressure gauges give different readings. (1)

6.2 State the principle you would use to explain your observation. (2)

The large piston of a small hydraulic lift in the sketch below has an area of 225 cm^2. A metal toy car with a mass of 1,5 kg is placed on the large piston of the hydraulic lift. The radius of the small piston is 1,75 cm.



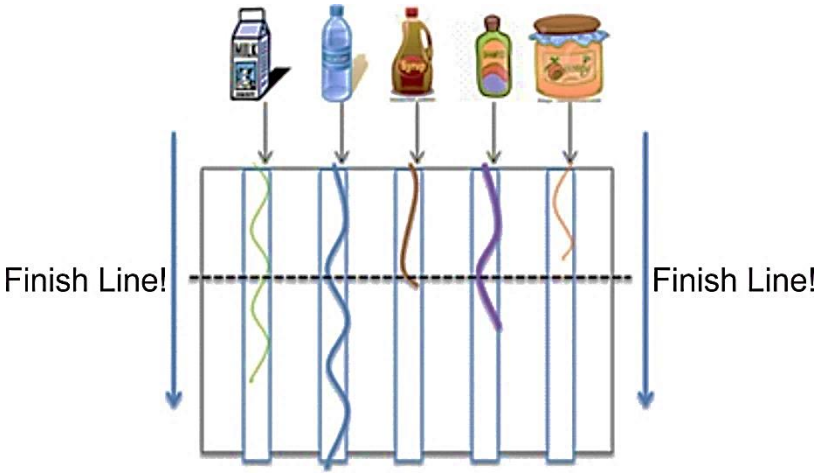
6.3 Convert 225 cm^2 to m^2. (2)

6.4 Calculate the minimum force required on the small piston to lift the car. (4)

6.5 Calculate the mechanical advantage of this hydraulic lift. (3)
[12]

QUESTION 7 (Start on a new page)

To illustrate the difference in viscosity a teacher set up a viscosity race in class between several household substances. The teacher used milk, water, syrup, shampoo and honey. The diagram below shows the results of the race. The liquids were placed on a plastic surface at an incline of 65°. The substances were released at the same time. The distance from the start line to the finish line is 10 cm. The diagram shows the results of the race after 10 seconds.



7.1 Identify the following variables for this experiment.

7.1.1 Controlled variable (1)

7.1.2 Independent variable (1)

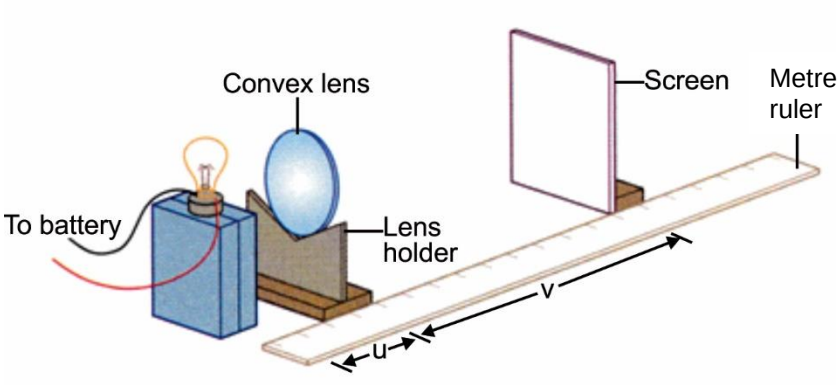
7.2 Which substance has the strongest intermolecular forces? (1)

7.3 Give a reason for your answer in **Question 7.2** by referring to intermolecular forces. (2)

7.4 How will the results change if the experiment is done in the sun? (2)
[7]

QUESTION 8 (Start on a new page)

During an experiment to determine the properties of an image formed through a convex lens the following setup was used.



8.1 Identify the following from the sketch:

8.1.1 U (1)

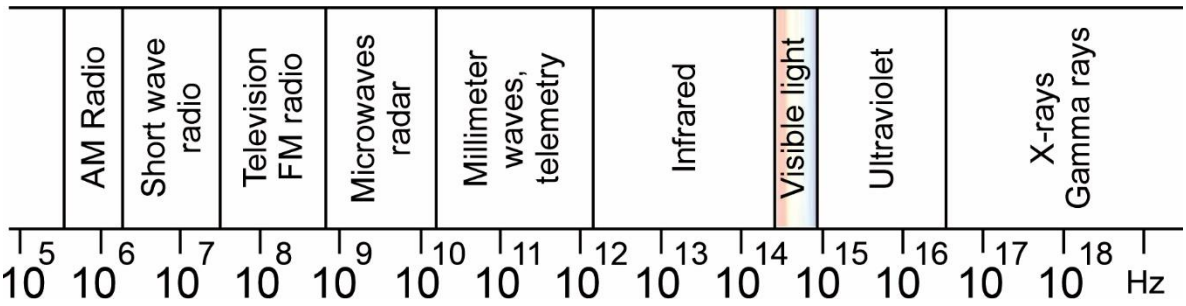
8.1.2 V (1)

8.2 Draw a light ray diagram to show the transmission of light through a convex lens, where the object is placed between F and 2F. (4)

8.3 Give three properties of an image formed when the object is placed between F and 2F in the diagram above. (3)

During an experiment it is determined that an electromagnetic wave has a wavelength of 3×10^{-7} m.

The electromagnetic spectrum



8.4 Define an *electromagnetic wave*. (2)

8.5 Determine the type of electromagnetic wave that was used during the experiment. Make use of the table above. (4)

8.6 Calculate the energy of a photon of the electromagnetic wave in **Question 8.5**. (3)

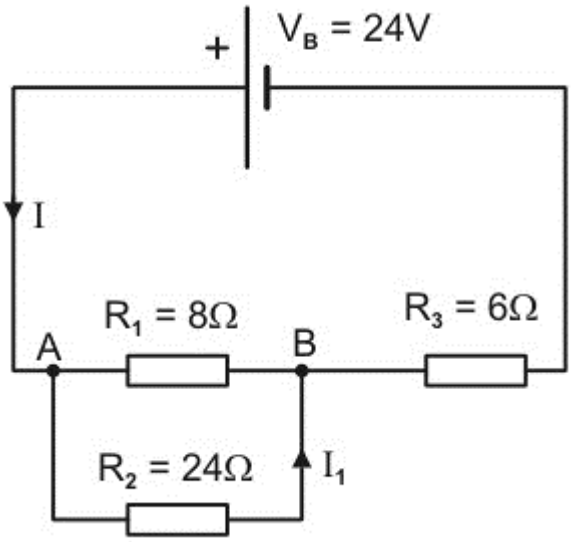
8.7 Give two properties of an electromagnetic wave. (2)

[20]

QUESTION 9 (Start on a new page)

Study the circuit diagram below and answer the questions that follow.

In the circuit below the cell has a potential difference of 24 V. The cell has negligible internal resistance.



9.1 Define *resistance.* (2)

9.2 Calculate the total resistance in the circuit. (4)

9.3 Calculate the current (*I*) through the circuit. (3)

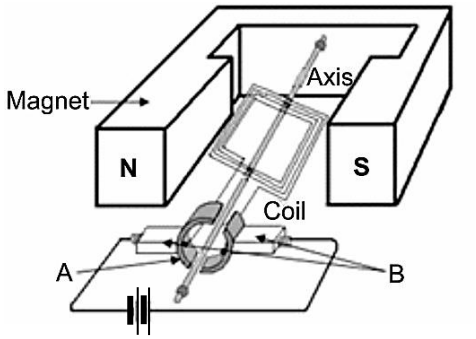
9.4 Calculate the potential difference across **A** and **B**. (2)

9.5 Calculate the current through the **24 Ω** resistor. (2)

9.6 Calculate the power dissipated in resistor $\mathbf{R_3}$. (3)
[16]

QUESTION 10 (Start on a new page)

The diagram below represents a simplified drawing of an electric device.



10.1 What is this type of electric device called? (1)

10.2 In which direction is the coil rotating? Write only **CLOCKWISE** or **ANTICLOCKWISE**. (2)

10.3 Which rule did you use to determine the direction in which the coil is rotating in **Question 10.2**? (1)

10.4 Give the energy conversion that takes place in this electric device. (1)

10.5 State *Faraday's law of electromagnetic induction*. (2)

10.6 A transformer has 3 kV and 1 000 turns on the primary coil. How many turns are required on the secondary coil to produce an output voltage of 240 V? (4)

[11]

Total: 150 marks