NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2020

TECHNICAL SCIENCES: PAPER I

Time: 3 hours 150 marks

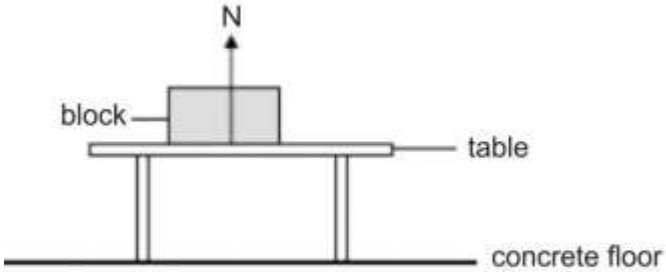
PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 13 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 in the question paper.
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 SHEETS.
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) next to the question number (1.1–1.10) in the ANSWER BOOK, for example 1.11 D.

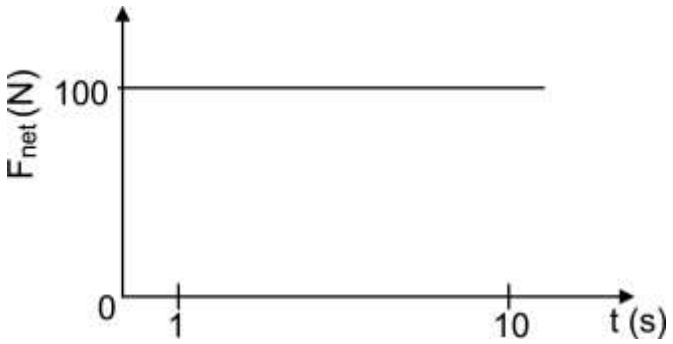
1.1 A block rests on a table. The table stands on a concrete floor. The normal force is represented by N, as shown in the diagram below.



Which ONE of the following forces will form an action-reaction pair with the normal force (N)?

A Force of the block on the Earth.
B Force of the block on the table.
C Force of the table surface on the block.
D Force of the block on the concrete floor. (2)

1.2 The sketch graph below may be used to calculate the impulse of a constant net force of 100 N that acts on an object over a period of time.



Which ONE of the following can be used to calculate the impulse (in kg·m·s^{-1}) of the force for the time interval t = 1 s to t = 10 s?

A 100 × 1
B 100 × 10
C 100 × 9
D 10 × 9 (2)

1.3 A constant net force acts on a trolley.

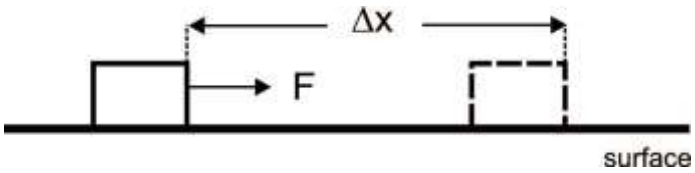
According to Newton's second law, the acceleration of the trolley is … the mass of the trolley.

A equal to
B independent of
C directly proportional to
D inversely proportional to (2)

1.4 The gravitational potential energy of an object relative to the ground is dependent on the object's …

A speed.
B position.
C velocity.
D acceleration. (2)

1.5 A constant horizontal force **F** displaces a box by Δx over a rough horizontal surface. Study the diagram below.



The normal force acting on the box does NO work on the box during the motion, because it is …

A equal to the applied force.
B perpendicular to the applied force.
C equal and opposite to the weight of the box.
D perpendicular to the displacement of the box. (2)

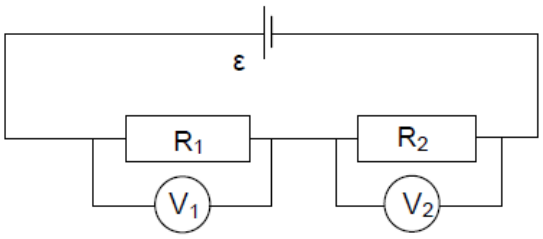
1.6 In an experiment to determine the modulus of elasticity for a piece of copper wire, the length of the wire and the suspended mass are doubled. Then the modulus of elasticity of the wire …

A will also double.
B will be four times larger.
C will remain unchanged.
D will be halved. (2)

1.7 When a PN-junction is forward bias.

A Electrons in the N-region are injected into the P-region.
B Holes in the P-region are injected into the N-region.
C Both A and B.
D No movement of holes or electrons because of the depletion region. (2)

1.8 The diagram below shows a cell of emf (ε), and two resistors, R_1 and R_2, in series, with $R_1 < R_2$. The cell has negligible internal resistance and the voltmeters have very high resistances.



Which ONE of the following is CORRECT?

A $V_1 = V_2 = \varepsilon$
B $V_1 > V_2$
C $\frac{V_1}{R_1} = \frac{V_2}{R_2}$
D $\frac{V_1^2}{R_1} > \frac{V_2^2}{R_2}$ (2)

1.9 A device that converts electrical energy into mechanical energy is a/an …

A AC generator.
B DC generator.
C transformer.
D DC motor. (2)

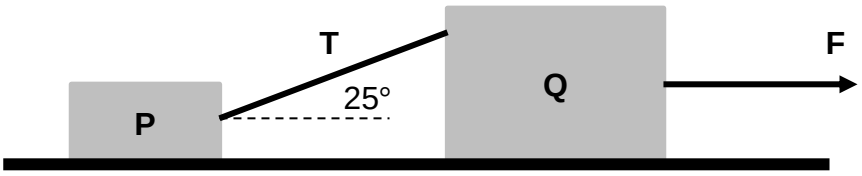
1.10 The working principle of a transformer depends on …

A Ohm's law.
B Lenz's law.
C Fleming's rule.
D Faraday's law. (2)

[20]

QUESTION 2

Two blocks, **P** and **Q**, resting on a rough horizontal surface, are connected by a light inextensible string. The string forms an angle of 25˚ to the horizontal. The blocks have masses 5 kg and 8 kg respectively. A constant force **F** is applied to the 8 kg block, as shown below.



The two blocks now move to the **RIGHT** at a CONSTANT SPEED of 3 $m \cdot s^{-1}$.

2.1 State *Newton's first law of motion* in words. (2)

2.2 Draw a labelled free-body diagram for **block P**. (4)

The tension in the string between the blocks is **5 N**.

2.3 Calculate the horizontal component of the tension in the string (**T**). (2)

Block **P** and **Q** experience constant frictional forces of 2,5 N and 1 N respectively.

2.4 State the definition of a *net force* (resultant force) in words. (2)

2.5 Calculate the magnitude of force **F**. (3)

The string connecting **P** and **Q** suddenly breaks while force **F** is still being applied.

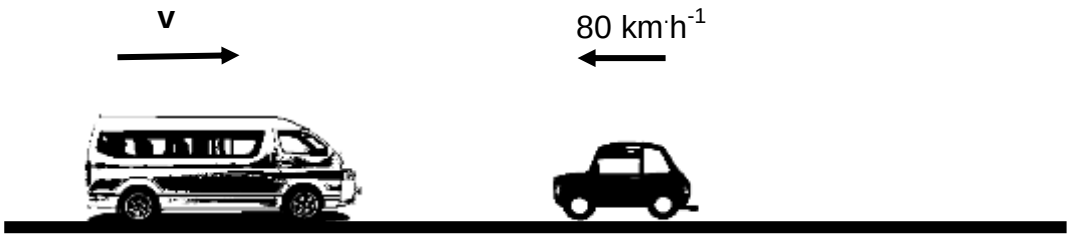
2.6 Is the direction of the acceleration of block **Q** now towards **LEFT** or **RIGHT**? Explain your answer. (3)

2.7 How will the net force acting on block **P** be affected when the string breaks? Choose from INCREASES, DECREASES or REMAINS THE SAME. (1)

[17]

QUESTION 3

A minibus taxi of mass 5 800 kg, moving at a velocity **v** to the right collides head on with a car of mass 1 500 kg moving at 80 $km \cdot h^{-1}$ in the opposite direction. Immediately after the collision, the car and the taxi move at 6 $m \cdot s^{-1}$ and 10 $m \cdot s^{-1}$, respectively to the right.



3.1 Convert the car's speed to $m \cdot s^{-1}$. (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 minibus taxi before the collision. (4)

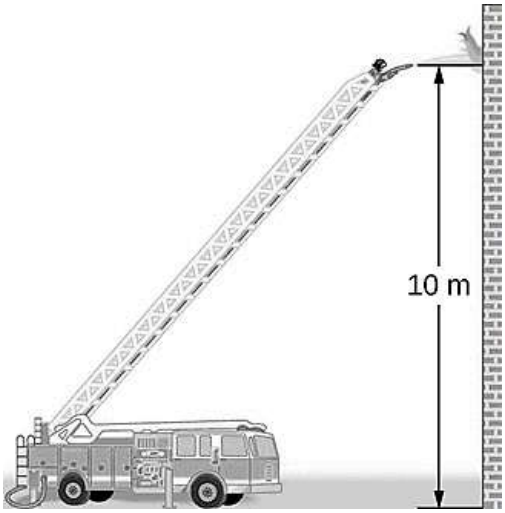
3.4 If the collision lasts 0,2 seconds, calculate the force the car exerts on the minibus taxi during the collision. (4)

3.5 What is the magnitude of the force that the minibus taxi exerts on the car? Give a reason for your answer. (2)

3.6 Give two safety precautions that modern cars have to protect its occupants in case of a collision. (2)
[16]

QUESTION 4 (Start on a new page)

A fire-truck arrives at a building that is on fire. It uses a water pump to pump the water up the hose to extinguish the flames, as shown in the diagram below. The water pump converts kinetic energy to hydro-dynamic energy.



4.1 Define the term *energy.* (2)

The firefighter at the top of the ladder looks down at the ground and his helmet falls off his head. The helmet has a mass of 1,2 kg. Ignore the effect of air resistance.

4.2 Calculate the gravitational potential energy of the helmet at the top of the ladder. (3)

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

4.4 Calculate the magnitude of the velocity with which the helmet reaches the ground. (3)

The ground is very muddy due to the water used to extinguish the fire. The helmet drops into the mud and comes to rest after 0,6 s at a depth of 20 cm in the mud.

4.5 Calculate the work done by the mud, if the force of resistance of the mud is 650 N. (4)

4.6 If the water pump converts $4{,}8 \times 10^5$ J of energy in 2 minutes, calculate the average power of the pump. (4)

4.7 Convert your answer in **Question 4.6** to horsepower. (2)

4.8 The water is pumped at a constant velocity of 10 $m \cdot s^{-1}$. Determine the magnitude of the force generated by the water pump. (3)

[23]

QUESTION 5

Modern day bungee jumping began on 1st April 1979.

Hooke's law tells us that the elastic bungee cord will stretch by a known amount for each person depending on their weight. During an experiment to test the elasticity of bungee cords, the following apparatus was used in the laboratory.

A bungee cord with a length of 0,75 m and diameter of 20 mm was used during the experiment. A mass piece of 20 kg was hung from the end of the bungee cord. The cord elongated by 50%.

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

5.2 Calculate the stress experienced by the bungee cord. (4)

5.3 Calculate the change in length of the cord. (2)

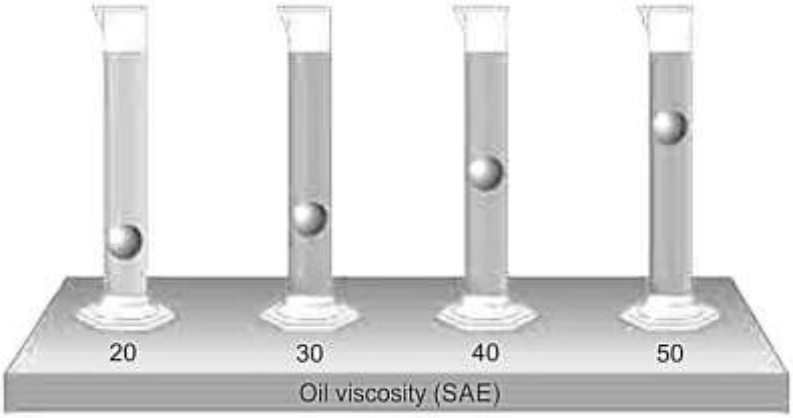
5.4 Calculate the strain of the bungee cord. (3)

5.5 Calculate the elasticity modulus for this bungee cord. (3)

5.6 Define a *perfectly plastic body*. (2)
[16]

QUESTION 6

During an experiment to test the viscosity of single-grade motor oils, steel marbles of equal mass are dropped into measuring cylinders containing different SAE-grade motor oils. The diagram below shows the position of the marbles after 10 s. The experiment is conducted at room temperature.



6.1 Give the complete definition for *viscosity*. (2)

6.2 Identify the following variables for this experiment:

6.2.1 Controlled variable. (1)

6.2.2 Independent variable. (1)

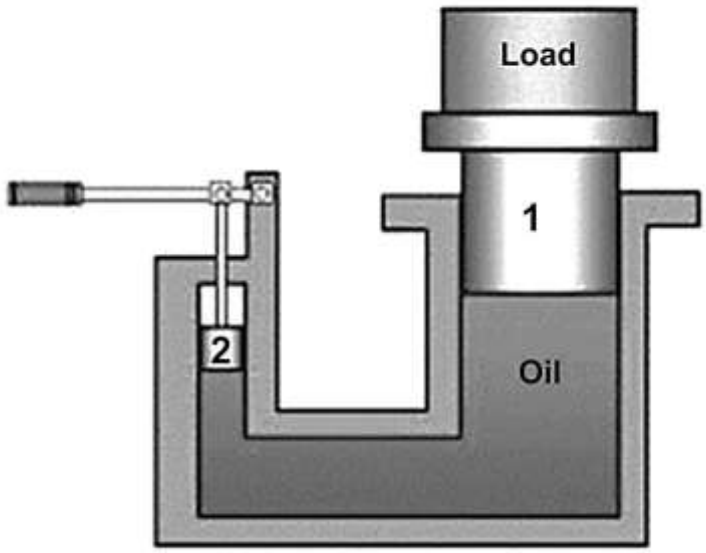
6.2.3 Dependant variable. (1)

6.3 What will be observed if the experiment was repeated at a temperature of 50°C? (2)

6.4 Explain your answer in **Question 6.3** by referring to intermolecular forces. (3)
[10]

QUESTION 7

The large piston of the hydraulic lift in the sketch below has an area of 325 cm^2. A maximum force of 550 N can be applied on the small piston. The radius of the small piston is 1,75 cm.



7.1 State *Pascal's principle* in words. (2)

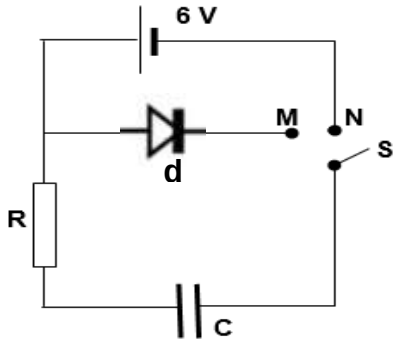
7.2 Convert 325 cm^2 to m^2. (2)

7.3 Calculate the maximum mass that can be lifted by this hydraulic lift. (6)

[10]

QUESTION 8

A 6 V battery, a resistor, a capacitor, a diode, and a switch, S, are connected in a circuit as shown in the diagram below. Switch S can be closed at either position M or position N.



Switch **S** is initially at position N, charging the capacitor.

8.1 What is meant by the term *dielectric.* (2)

8.2 State two ways in which the capacitance of a capacitor (C) can be increased (2)

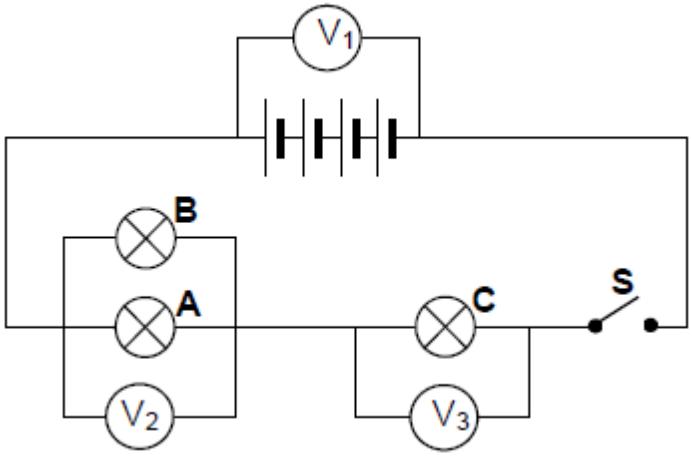
8.3 Define the term *capacitance of a capacitor*. (2)

The switch S is now moved to position **M**.

8.4 State weather the diode component **d** is connected in **forward** or **reverse** bias. (1)
[7]

QUESTION 9

Learners set up a circuit as shown in the diagram below. The emf of each cell is 1,5 V. Each of the bulbs **A** and **B** has a resistance of 2 Ω and bulb **C** has a resistance of 3 Ω.



9.1 Calculate the effective resistance of bulbs **A** and **B**. (3)

Switch **S** is now closed for a short time.

9.2 Define *Ohm's law* in words. (2)

9.3 Determine the reading on:

9.3.1 Voltmeter V_1 (1)

9.3.2 Voltmeter V_3 (2)

9.4 Calculate the energy transferred in bulb **C** in 3 minutes if the current in the circuit is 1,5 A. (4)

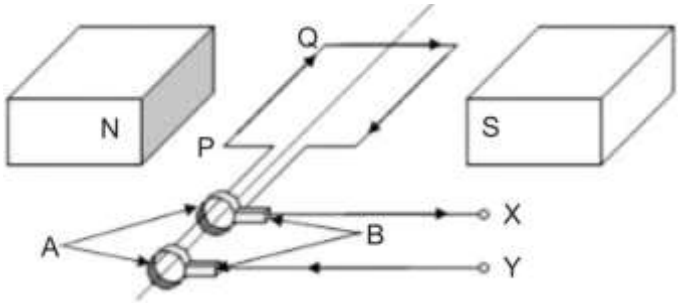
9.5 Define the term *power* as it pertains to electricity. (2)

9.6 ALL the bulbs are now connected in parallel. How will the total current in the circuit be affected? Write down only INCREASES, DECREASES or REMAINS THE SAME. (1)

[15]

QUESTION 10

10.1 The output potential difference of a generator is 100 V. It takes 0,05 s to complete one rotation of the coil. A simplified diagram of the generator is shown below. The direction of the induced current in the coil is from **P to Q**.



10.1.1 In which direction is the coil rotating? Write only **CLOCKWISE** or **ANTICLOCKWISE**. (1)

10.1.2 Sketch a graph of the output potential difference versus time when the coil completes **TWO full cycles**. On the graph, clearly indicate the maximum potential difference (100 V) and the time taken to complete the two cycles. (3)

10.1.3 Supply labels for the following components in the sketch.

(a) Component A. (1)

(b) Component B. (1)

10.1.4 What type of generator is represented by the sketch above? (1)

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

10.2 A coil with 480 winding moves perpendicular through a magnetic field. The rate at which the magnetic flux changes is $1,6 \times 10^{-3}$ $Wb \cdot s^{-1}$.

10.2.1 Calculate the induced emf. (4)

10.2.2 Calculate the current in the coil if the resistance of the coil is 1,5 Ω. (3)

[16]

Total: 150 marks