NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2019

TECHNICAL SCIENCES: PAPER I

Time: 3 hours 150 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 14 pages and a Data Sheet of 2 pages (i–ii). Please check that your question paper is complete.
2. This paper consists of ELEVEN 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 Frictional force …

A is opposite the direction of motion of an object and acts perpendicular to the surface the object is in contact with.
B is in the same direction as the motion of an object and acts parallel to the surface the object is in contact with.
C is in the same direction as gravitational force.
D opposes the motion of an object and acts parallel to the surface the object is in contact with. (2)

1.2 If the resultant (net) force acting on an object is zero, the object …

A slows down.
B accelerates uniformly.
C changes its direction of motion.
D continues moving with constant velocity. (2)

1.3 A boy sits on a chair. According to Newton's Third Law, the reaction force on the boy's weight is ...

A the force of the boy on the chair.
B the force of the chair on the boy.
C the force of the Earth on the boy.
D the force of the boy on the Earth. (2)

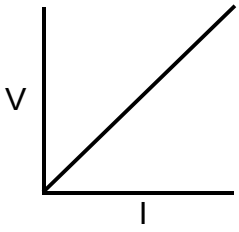
1.4 A piece of silicon that is doped with elements of group III becomes a …

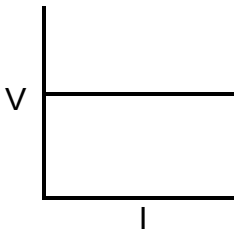
A P-Type semiconductor.
B N-Type semiconductor.
C III-Type semiconductor.
D superconductor. (2)

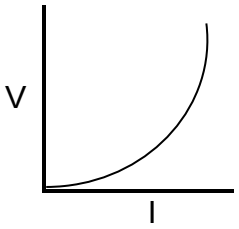
1.5 An example of an intrinsic semiconductor is?

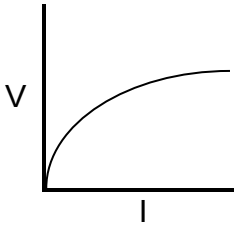
A Tin
B Phosphorus
C Boron
D Magnesium (2)

1.6 Which one of the following graphs correctly represents the relationship between potential difference (V) and current (I) for an ohmic conductor?

A 

B 

C 

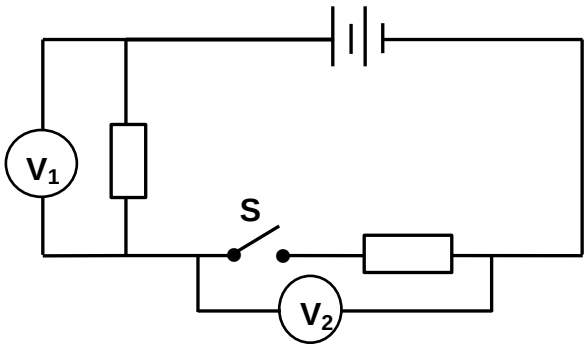
D 

(2)

1.7 When a potential difference of 220 V is maintained across a capacitor with a capacitance of 50 F, the capacitor will store … coulomb of charge.

A 4400
B 11 000
C 0,227
D 270 (2)

1.8 A battery with negligible internal resistance is connected to two resistors as shown in the diagram below. The switch **S** is OPEN.



Switch **S** is now CLOSED.

How will the readings on voltmeters $\mathbf{V_1}$ and $\mathbf{V_2}$ change?

	READING ON V_1	**READING ON V_2**
A	Increases	Increases
B	Decreases	Increases
C	Increases	Decreases
D	Decreases	Decreases

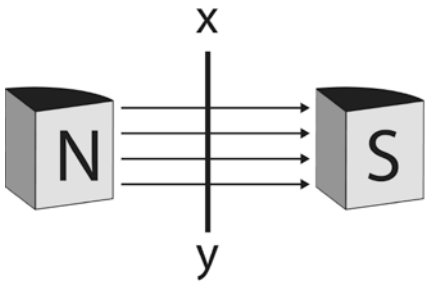
(2)

1.9 Which ONE of the following combinations represents the component(s) present AS WELL AS the energy conversion in a direct current (DC) motor?

	Component	**Energy Transfer**
A	Split ring commutator	Electrical to mechanical energy
B	Slip rings	Mechanical to electrical energy
C	Slip rings	Electrical to mechanical energy
D	Split ring commutator	Mechanical to electrical energy

(2)

1.10 A conducting wire, **XY**, moves between two magnets as shown below.



Which ONE of the following actions can lead to an increased induced current in wire **XY**?

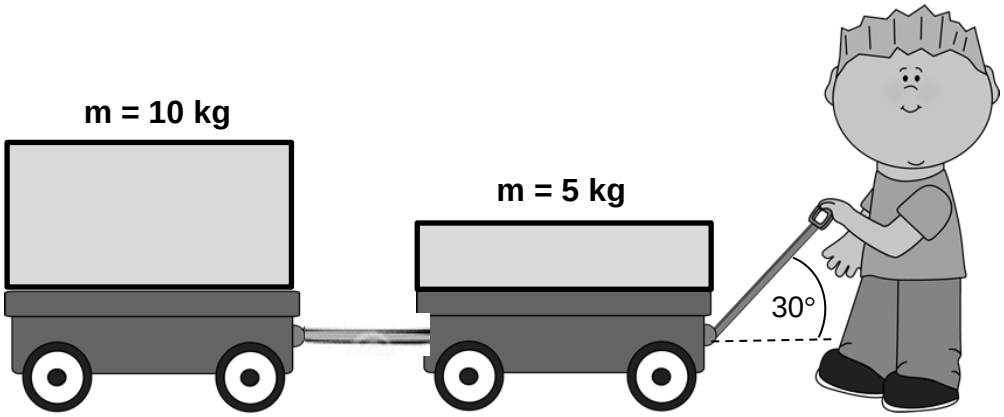
Move the wire …

A quickly and parallel to the magnetic field.
B slowly and parallel to the magnetic field.
C quickly and perpendicular to the magnetic field.
D slowly and perpendicular to the magnetic field. (2)

[20]

QUESTION 2

A boy is pulling two trolleys with masses 5 kg and 10 kg, with a force of 50 N at an angle of 30^{o} to the horizontal, over a frictionless surface, as shown in the following diagram.



2.1 Draw a labelled free body diagram for the 5 kg trolley. Indicate all the forces acting on the trolley. (4)

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

2.3 Apply Newton's Second Law of Motion to calculate the acceleration of the system. (6)

2.4 Determine the tension in the rope between trolley A and B. (2)

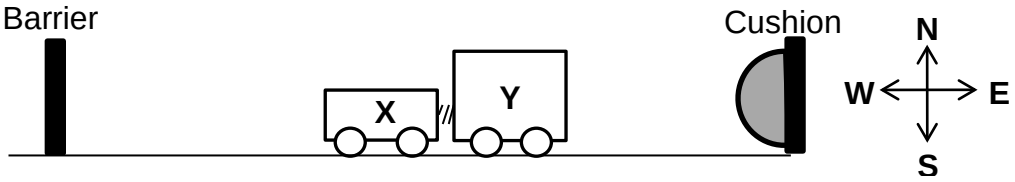
2.5 Define *acceleration*. (2)

2.6 How will the acceleration change if friction was accounted for? Use Newton's Second Law of Motion to explain your answer. (2)

[18]

QUESTION 3

Trolley **X** with a mass **250 g** is placed against trolley **Y** with mass **750 g**, as shown in the diagram below. A compressed spring between the two trolleys releases in 0,3 s and the trolleys move in opposite directions. Trolley **X** moves west and hits a barrier after time **t**.



The table below gives the position of trolley **X** for time intervals of 0,3 seconds:

Position (m)	0	1,38	2,88	4,38	5,88	7,38	7,38	7,38
Time (s)	0	0,3	0,6	0,9	1,2	1,5	1,8	2,1

3.1 At which time **t** does the trolley **X** hit the barrier? (1)

3.2 Explain, with reference to the values in the table, why trolley **X** moves with a constant speed between t = 0,3 s and t = 1,5 s. (2)

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

3.4 Calculate the speed of trolley **Y** after the spring is released. (5)

3.5 Define *impulse*. (2)

3.6 Calculate the force that is exerted on trolley Y. (4)

Trolley Y collides with the cushion and bounces back at a speed of 3,25 $m \cdot s^{-1}$.

3.7 Define the following:

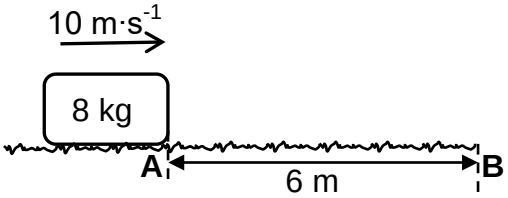
3.7.1 An elastic collision (2)

3.7.2 An inelastic collision (2)

[20]

QUESTION 4

A block of mass 8 kg moves over a rough horizontal surface from point A to B as shown in the following diagram.



4.1 Define the term *energy.* (2)

4.2 Calculate the kinetic energy of the block at point A. (3)

The coefficient of kinetic friction (μ_k) between the block and the surface AB is 0,15.

4.3 Calculate the magnitude of the kinetic frictional force on the block while moving from point A to B. (3)

4.4 Calculate the work done by the kinetic frictional force from point A to point B. (3)
[11]

QUESTION 5

The following diagram shows a wrecking ball with mass 1,5 tons hanging from a crane on a cable. The crane winds up the cable so that the ball moves **upwards** at a **constant velocity** of 2 $m \cdot s^{-1}$.

After 3 seconds the crane stops winding the cable. The ball stops and reaches a height of 6 m above the ground.

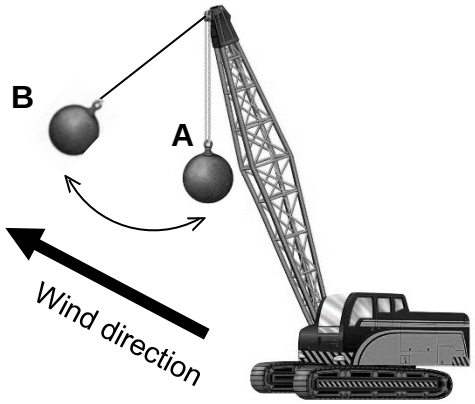
5.1 Define *power*. (2)

5.2 Calculate the weight of the ball. (3)

5.3 Calculate the power of the crane motor as it winds up the cable. (4)

5.4 Convert your answer in **Question 5.3** to horsepower. (2)

A strong wind starts to blow and the ball starts to swing in the direction of B, as indicated in the diagram below.



The ball reaches a maximum height at point B of 7,5 m above the ground.

5.5 Calculate the gravitational potential energy of the ball at point B. (3)

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

5.7 Calculate the speed of the ball at point A when it swings back. (4)

[20]

QUESTION 6

When a tensile stress of 5×10^6 Pa is applied to the ends of a round bar, it is desired that the strain is about 5×10^{-4}. The length of the round bar is 120 cm.

Type of material	Young's modulus
Rubber	3×10^7 Pa
Wood	1×10^{10} Pa
Brass	1×10^{11} Pa
Iron	1×10^{12} Pa

Make use of the table above to answer the following.

6.1 State *Hooke's Law* in words. (2)

6.2 What would be the most appropriate material to use for this bar? (Make use of a calculation to determine your answer.) (4)

6.3 Calculate the change in length of the bar. (4)

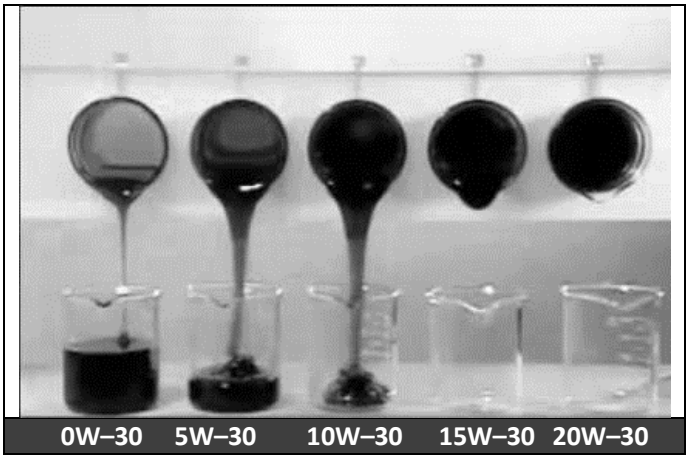
6.4 Define *stress*. (2)

6.5 If a force of 9800 N is applied to obtain this tensile stress, what is the cross section area of the bar? (3)

[15]

QUESTION 7

During an experiment, five motor oils with different gradings are used to indicate the difference in viscosity of motor oils. The experiment is set up as indicated in the diagram below. The experiment is performed at –20 °C.



7.1 Give a complete definition for *viscosity*. (2)

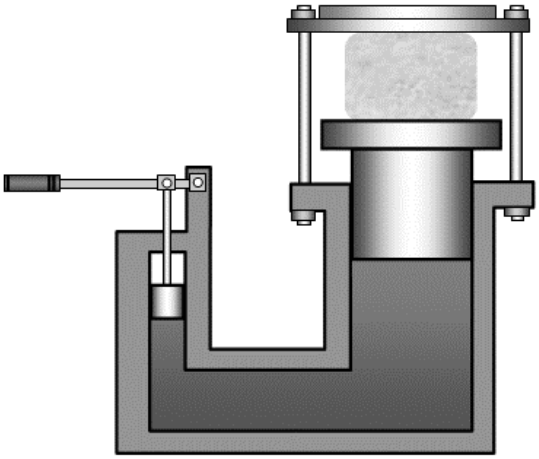
7.2 Which oil has the highest viscosity? (1)

7.3 What is the meaning of the SAE value 10W–30. (3)

[6]

QUESTION 8

A hydraulic press for compacting powdered samples has a large cylinder which has a diameter of 11,8 cm, and a small cylinder with an area of $3{,}02 \times 10^{-4}$ m^2. A lever is attached to the small cylinder as shown. The sample which is placed on the large cylinder, has a cross sectional area of 4,09 cm^2.



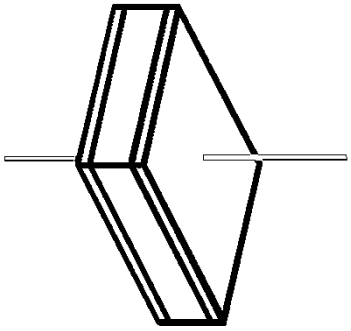
8.1 State *Pascal's Law* in words. (2)

8.2 Calculate the area of the large cylinder in m^2. (3)

8.3 A force of 319 N is applied on the lever. Calculate the output force exerted in the larger piston. (4)
[9]

QUESTION 9

A capacitor is a component used in an electric circuit to store electrical charge.



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

9.2 Name the three factors that influence the capacitance of a capacitor. (3)

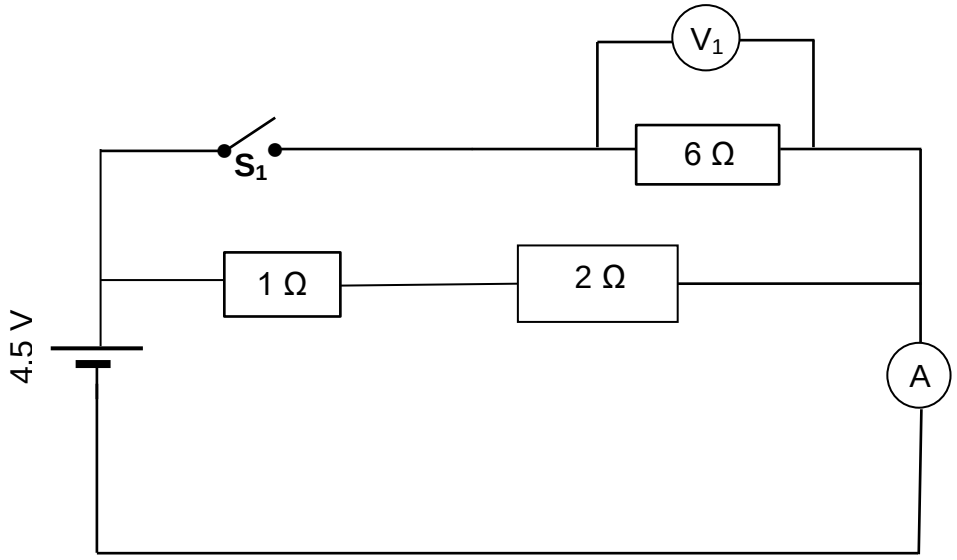
9.3 A capacitor consists of two square metal plates, of length 2 cm, that are separated by an air gap of 3 mm.

Calculate the potential difference across the capacitor plates if each plate can store 6×10^{-11} C of charge. (5)

[10]

QUESTION 10

A cell with an emf (ε) of 4,5 V is connected in a circuit as shown in the diagram below.



10.1 Which device in the circuit diagram measures the rate of flow of charge? Write down only VOLTMETER or AMMETER. (1)

10.2 State *Ohm's Law* in words. (2)

Switch **S_1** is now closed.

10.3 What is the reading on Voltmeter V_1. (1)

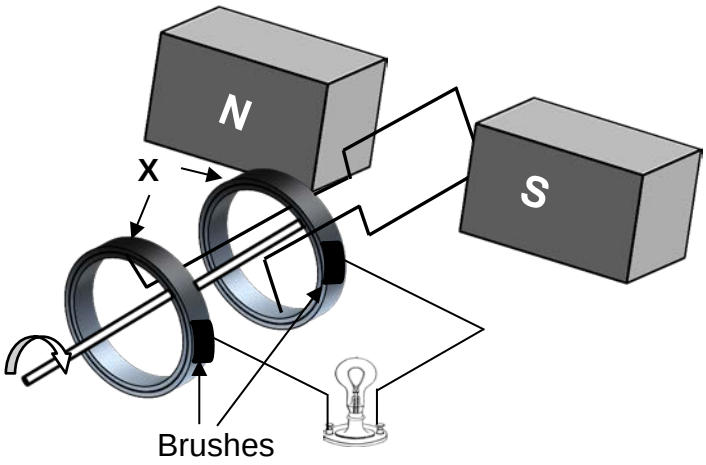
10.4 Calculate the current strength through the **6 Ω** resistor. (3)

10.5 Define *power* as it pertains to electrical circuits. (2)

10.6 Calculate the energy conversion that takes place in the **6 Ω** resistor. (3)
[12]

QUESTION 11

11.1 The diagram below represents a simplified drawing of an electric device that is connected to a light bulb.



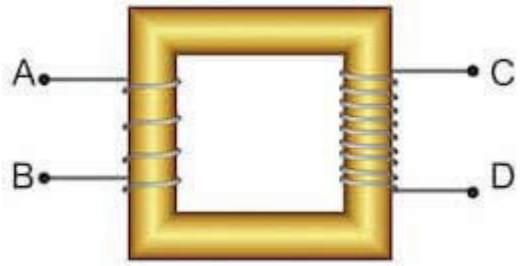
11.1.1 What is this type of electric device called? (1)

11.1.2 Write down the principle on which the device operates. (1)

11.1.3 Write down ONE method to increase the brightness of the bulb. (1)

11.1.4 Identify component **X** in the diagram. (1)

11.2 The following diagram represents the basic structure of a transformer.



11.2.1 To which contact points, AB or CD, must the input voltage be connected so that the transformer can function as a step-up transformer. (1)

11.2.2 A cellphone requires a 4,5 V output voltage. The cellphone charger is connected to a 240 V alternating current source. Calculate the number of windings on the secondary coil if the primary coil has 1000 windings. (4)

[9]

Total: 150 marks