



**ZIMBABWE**

**MINISTRY OF HIGHER AND TERTIARY EDUCATION,  
INNOVATION, SCIENCE AND TECHNOLOGY DEVELOPMENT**

**HIGHER EDUCATION EXAMINATIONS COUNCIL  
(HEXCO)**

**NATIONAL CERTIFICATE**

**IN**

**MOTOR VEHICLE MECHANICS, AUTOMOBILE ELECTRICS AND ELECTRONICS,  
DPF, PRECISION MACHINING, MVBP AND MOTOR CYCLE MECHANICS**

**SUBJECT: Automotive Engineering Science**

**PAPER NO: 346/18/S09  
346/13/S09**

**DURATION: 3 hours**

**MARCH/APRIL 2022 EXAMINATION**

**REQUIREMENTS**

1. Pen
2. Pencil
3. Eraser
4. Drawing instruments
5. Scientific calculator

**INSTRUCTIONS TO CANDIDATE**

1. Section A: Answer ALL questions [40 marks].
2. Section B: Answer any five (5) questions [60 marks]. Each question carries 12 marks.

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*This paper consists of 5 printed pages.*

**SECTION A [40 marks]**

**Answer all questions.**

QUESTION 1

1.1 If  $a = 2i - j + 3k$   
 $b = 3i + 2j - 4k$   
 $c = -i + 3j - 2k$

Find:

- i)  $a + b$  (1 mark)
- ii)  $a - b$  (1 mark)
- iii)  $|c|$  (1 mark)

1.2 A vehicle reduces its velocity to a standstill over a displacement of 500m with a retardation of  $10m/s^2$ . Calculate its initial velocity. (3 marks)

1.3 A force of 160N acts uniformly over an area of  $8m^2$ . What is the pressure on the area. (3 marks)

1.4 Define the term energy. (2 marks)

1.5 A material may exist in one of the three states: \_\_\_\_\_, \_\_\_\_\_ or \_\_\_\_\_ (3 marks)

1.6 Differentiate between potential energy and kinetic energy. (2 marks)

1.7 Calculate the amount of heat energy required to raise the temperature of 8kg of copper from 20°C to 40°C if the specific heat capacity is 390J/kg K. (2 marks)

- 1.8 i)  $1N/mm^2 =$  \_\_\_\_\_ MPa. (1 mark)
- ii) Define tractive resistance. (2 marks)
- iii) State any one method of heat transfer. (1 mark)

- 1.9 i) Define friction. (1 mark)
- ii) A metal casting weighing 250kg is dragged along a concrete floor surface by a force of 1.2kN. determine the coefficient of friction between the casting and the concrete floor surface. Take  $g = 10m/s^2$ . (1 mark)

- 1.10 A wire 3m long and 3.15m diameter is extended by 0.9mm when a tensile force of 200N is applied to it. Calculate Young's modulus of elasticity for the material if the wire, assuming that the elastic limit is not exceeded. (6 marks)
- 1.11 State the principle of moments. (2 marks)
- 1.12 i) Convert a speed of 60km/hr into units of m/s. (2 marks)
- ii) Differentiate between velocity and speed. (2 marks)
- iii) Define the term momentum. (2 marks)

**SECTION B [60 marks]**

**Answer any five (5) questions.**

QUESTION 2

A hand brake has a leverage of 8:1. The hand brake cable has an initial length of 2m and cross-sectional area of  $20\text{mm}^2$ . Determine:

- a) The stress in the cable when the driver applies a force of 100N to the hand brake. (6 marks)
- b) The strain in the cable when it is extended by 0,4mm. (3 marks)
- c) The modules of elasticity for the material of the cable. (3 marks)

QUESTION 3

A disc brake rotates at a velocity of 250 rev/min. A pair of friction pads act at a mean radius of 0,15m and the coefficient of friction between the pads and the disc is 0,32. The diameter of the brake cylinder is 50mm and the hydraulic oil pressure is  $600\text{kN/m}^2$ . Calculate:

- a) the total braking force on the disc. (4 marks)
- b) the torque acting on each disc. (4 marks)
- c) the heat generated per second. (4 marks)

QUESTION 4

During a constant load, constant speed test carried out on a single cylinder, four stroke petrol engine of cylinder bore diameter 75mm and stroke 100mm, the following readings were recorded:

|                |   |                                     |
|----------------|---|-------------------------------------|
| speed          | = | 25000 rev/min                       |
| i.m.e.p        | = | 860kN/m <sup>2</sup>                |
| net brake load | = | 75N at an effective radius of 0.35. |

Determine:

- |                              |           |
|------------------------------|-----------|
| a) the i.p.                  | (5 marks) |
| b) the b.p.                  | (3 marks) |
| c) the f.p.                  | (2 marks) |
| d) the mechanical efficiency | (2 marks) |

QUESTION 5

A trolley jack requires an effort of 200N to lift a load of 2 tonnes. In lifting the load through a distance of 150mm, the operator performs 40 pumping strokes of the handle each of which is 500mm long. Calculate the mechanical advantage, movement ratio and efficiency of the jack. Take  $g = 10\text{m/s}^2$ . (12 marks)

QUESTION 6

A uniform beam AB of length 8m is simply supported at its ends. It carries point loads of 4kN, 5kN and 7kN at the position 2m, 5m and 7m respectively from end A. If the reaction at end B is 13kN, calculate:

- |                                          |            |
|------------------------------------------|------------|
| a) The force due to gravity on the beam. |            |
| b) The reaction at end A.                | (12 marks) |

QUESTION 7

Steel components of mass 10kg are quenched in oil from a temperature of 760°C. The oil has a mass of 1200kg and is contained in a steel tank of mass 50kg. The initial temperature of the oil and tank is 20°C. Determine the final temperature of the oil, tank and components assuming there is no heat transfer to the surroundings. For steel the specific heat capacity is 500J/kg k for oil, the specific heat capacity is 200J/kg k. (12 marks)

QUESTION 8

After being balanced, a grinding wheel was heated on its spindle and accelerated uniformly to its operating speed of 2 800 rev/min in 10 seconds when it was dressed. After dressing, power to the wheel was switched off and the wheel was allowed to come to rest, the deceleration of the wheel being assumed to be uniform.

If the wheel was running for a total time of 5 minutes and it took 2 minutes for it to come to rest, determine for the wheel:

- a) The angular acceleration (3 marks)
- b) The angular retardation (3 marks)
- c) The total number of revolutions made. (6 marks)

QUESTION 9

- a) A motor lorry has a mass of 4Mg and is driven up a hill of gradient 1 in 20 at a constant speed of 36km/hr. If the rolling resistance amounts to 75N/tonne, calculate the tractive effort exerted by the vehicle. (9 marks)
- b) If the engine is switched off, how far will the vehicle travel before coming to rest? (3 marks)

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