



**ZIMBABWE**

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

**HIGHER EDUCATION EXAMINATIONS COUNCIL  
(HEXCO)**

**NATIONAL CERTIFICATE**

**IN**

**AUTOMOBILE ELECTRICS AND ELECTRONICS, DIESEL PLANT FITTING,  
MOTOR VEHICLE MECHANICS, AUTOMOTIVE PRECISION, VEHICLE BODY  
REPAIR AND REFINISHING AND MOTOR CYCLE MECHANICS**

**SUBJECT: Automotive Engineering Science**

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

**DURATION: 3 Hours**

**OCTOBER / NOVEMBER 2024 EXAMINATION**

**REQUIREMENTS**

**Pen, pencil, scientific calculator, drawing instruments**

**INSTRUCTIONS TO CANDIDATE**

- 1. Section A: Answer all questions. This section carries 40 marks.**
- 2. Section B: Answer any five (5) questions.  
Each question carries 12 marks.**

**Section A: Answer all questions. This section carries 40 marks.**

QUESTION 1

- a) Express the following in the form of  $i, j$  and  $k$
- i)  $\begin{pmatrix} 2 \\ -3 \end{pmatrix}$  (1 mark)
- ii)  $\begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix}$  (1 mark)
- iii) Evaluate  $\begin{pmatrix} 2 \\ -3 \end{pmatrix} \cdot \begin{pmatrix} 1 \\ -5 \end{pmatrix}$  (2 marks)
- b) i) Convert 6 revolutions to radians in terms of  $\pi$ . (2 marks)
- ii) If a point on the circumference of a 500mm diameter wheel travels at a speed of 15m/s, calculate the angular velocity of the wheel in rad/s. (2 marks)
- c) Convert:
- i) 5000kN/mm<sup>2</sup> to MPa (1 mark)
- ii) 0,4g/cm<sup>3</sup> to kg/m<sup>3</sup> (1 mark)
- iii) 3000rev/min to rad/min (1 mark)
- iv) 400K to °F (1 mark)
- d) i) Explain the principle of conservation of energy. (2 marks)
- ii) Find the work done by a hydraulic hoist for lifting a vehicle of mass 1500kg to a height of 2m. (2 marks)
- e) i) Given that a 4 cylinder, two stroke engine produces 300 power strokes per second. Determine the speed of rotation of the crank shaft in rev/min. (2 marks)
- ii) Express the constant  $K$  of the dynamometer in terms of  $r$  and  $\pi$ , given that the arm radius of the machine is  $r$  metres. (2 marks)
- f) i) Name two (2) situations where friction has a useful application in a motor vehicle. (2 marks)
- ii) Distinguish between static friction and dynamic friction. (2 marks)



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- g) Define the following terms used in machines. (1 mark)
- i) Ideal effort (1 mark)
  - ii) Velocity ratio (1 mark)
  - iii) Mechanical advantage (1 mark)
  - iv) Limiting efficiency (2 marks)
- h) i) Explain Hooke's law. (2 marks)
- ii) A helical spring carrying a load of 500N is compressed by 20mm. Determine the spring stiffness. (2 marks)
- i) i) Distinguish between heat and temperature. (2 marks)
- ii) What is the difference between sensible and latent heat? (2 marks)
- j) i) Define the following in relation to forces acting at a given point. (1 mark)
- Resultant (1 mark)
  - Equilibrant (2 marks)
- ii) Explain the principle of moments. (2 marks)

**SECTION B**

QUESTION 2

A vehicle of mass 2 tonnes travels up a gradient inclined  $30^\circ$  to the horizontal at a constant speed of 54km/h. The frictional resistance is 200N/tonne and the gradient is 1.5km long, calculate:

- a) Total frictional / resistance (2 marks)
- b) Gradient resistance (2 marks)
- c) Total tractive resistance (2 marks)
- d) Work done in climbing the gradient (4 marks)
- e) Power used when climbing the gradient (2 marks)

$[g = 10m/s^2]$

QUESTION 3

A hydraulic jack has a plunger diameter of 40mm and a ram diameter of 80mm. If an effort of 200N is applied directly to lift a load, at efficiency of 40%, calculate:

- a) The load (6 marks)
- b) The number of pumping strokes made by the plunger to lift the load by 150mm, given that the length of a single stroke is 10mm. (6 marks)

QUESTION 4

A single plate clutch transmits a torque of 240Nm. The total spring force acting on the pressure plate is 3360N, and the coefficient of friction of the lining material is 0.3. Calculate the outside diameter of the lining if it had a width of 26mm. (12 marks)

QUESTION 5

A beam of mass 300kg has a length of 10m. The beam is supported at its ends, and carries a load of 1250N, 1,2m from the left end. Calculate the reactions at the support [ $g = 10m/s^2$ ]. (12 marks)

QUESTION 6

A quantity of steel rivets are hardened by heating to 900°C and plunging them into 400kg of oil which is at a temperature of 25°C. The temperature of oil must rise above 80°C for this operation. Determine the maximum mass of rivets that can be hardened. [Specific heat capacity of steel = 0,49kJ/kgK, specific heat capacity of oil = 2kJ/kgK]. (12 marks)

QUESTION 7

An engine is coupled to a dynamometer of an arm radius of 60cm and rotated at a speed of 3000 rev/min. Various brake loads were recorded as shown below:

| Cylinders working | ALL | 2, 3, 4 | 1, 3, 4 | 1, 2, 4 | 1, 2, 3 |
|-------------------|-----|---------|---------|---------|---------|
| Brake force (N)   | 64  | 43      | 42.4    | 42.93   | 43.46   |

Calculate:

- a) Constant K of the dynamometer. (2 marks)
- b) Brake power of the engine at 3000 rev/min. (2 marks)
- c) Indicated power of the engine at 3000 rev/min. (4 marks)
- d) Mechanical efficiency. (2 marks)
- e) Engine torque at 3000 rev/min. (2 marks)



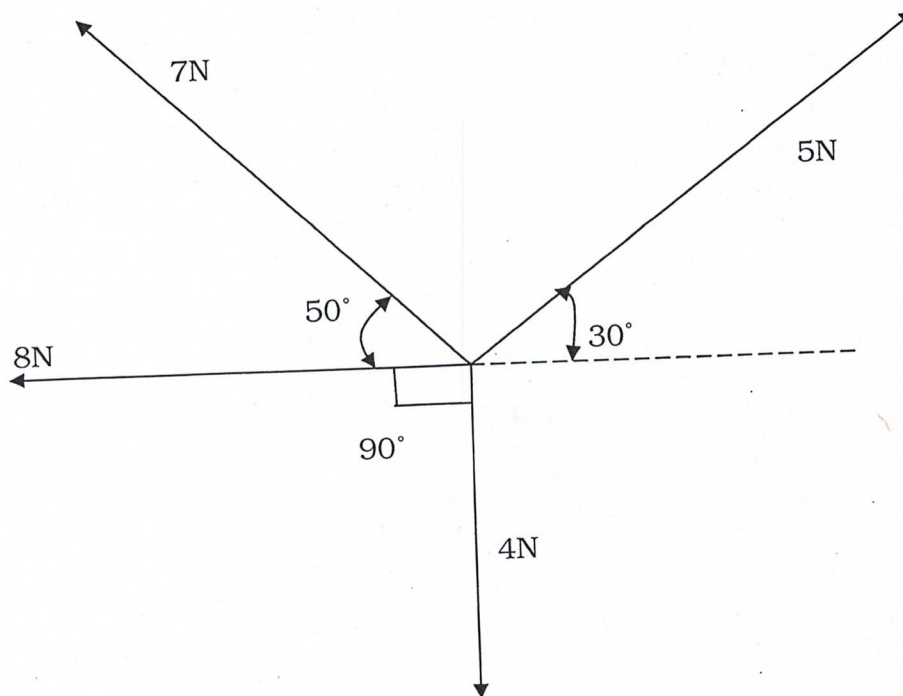
QUESTION 8

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

- The stress in the cable when the driver applies a force of 100N to the handbrake. (4 marks)
- The strain in the cable when it is extended by 0,4mm. (4 marks)
- The modulus of elasticity of the material. (4 marks)

QUESTION 9

Find the magnitude and direction of the resultant of four forces acting from the same point in the same plane as shown by the diagram below.



(12 marks)

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