



ZIMBABWE

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

**HIGHER EDUCATION EXAMINATIONS COUNCIL
(HEXCO)**

NATIONAL CERTIFICATE

IN

AUTOMOTIVE ENGINEERING

SUBJECT: Automotive Engineering Science PAPER NO: 346/13/S09

DURATION: 3 hours

MARCH/APRIL 2023 EXAMINATION

REQUIREMENTS

1. Graph paper
2. Pen
3. Pencil
4. Ruler
5. Scientific calculator

INSTRUCTIONS TO CANDIDATE

1. Section A: Answer all questions (40 marks).
2. Section B: Answer any five (5) questions.

This paper consists of 6 printed pages.

QUESTION 1

- a) State the law of inertia (2 marks)
- b) If. $a = i + 4j + 6k$
 $b = 2i - 3j + 8k$
- Find i) $|a|$ (2 marks)
ii) $|b - a|$ (3 marks)
- c) Give standard unit of:
- i) angular velocity (1 mark)
- ii) brake mean effective pressure (1 mark)
- d) Calculate the (K.E) kinetic energy possessed by a vehicle having mass of 3.05 tonne travelling at 85km/h (3 marks)
- e) State three (3) examples where friction is useful in a car (3 marks)
- f) Calculate the braking force required to stop a car in 20m when travelling at 24.8m/s.
- Mass of the car is 1.5 tonne. (4 marks)
- g) State Hooke's law (2 marks)
- h) Calculate shear stress in a rivet of diameter 12.5mm is subjected to a load of 37.5KN. (4 marks)
- i) Differentiate between sensible heat and latent heat (2 marks)
- j) Convert $212^{\circ}F$ to $^{\circ}C$ (2 marks)

- k) i) State the law of the machine (2 marks)
- ii) A 75N force lifts a load of 450N while a 100N force lifts a load of 650N.
- Determine the law of the machine (4 marks)
- l) Define centre of gravity (2 marks)
- m) If work done in moving a body is 1800J and time taken to move it is 16 seconds what is the power used? (3 marks)

SECTION B [60 marks]

Answer any five (5) questions.

QUESTION 2

A motorcycle accelerates with constant acceleration of $0.4m/s^2$ from rest for a period of 9 seconds and continues at this speed for 30 seconds before coming to rest in 4 seconds. The deceleration is constant. Sketch the V-t graph and determine the time taken to travel the first 24m and the total distance travelled. (12 marks)

QUESTION 3

- a) A machine exerts a force of 400N in lifting a mass through a height of 10m. If 5000J of energy is supplied to it, calculate the efficiency of the machine. (6 marks)
- b) The cross sectional area of an iron rod is $360mm^2$ and it is subjected to a tensile load of 24 000N. Calculate the factor of safety at which the iron rod is worked if the tensile strength of the iron is 400MPa. (6 marks)

QUESTION 4

- a) Find the heat required to raise the temperature of 15 litres of water from 10°C to 80°C . If heat is supplied in 6 minutes, what is the heat flow rate. (The specific heat capacity of water is 4.2kJ/kgK) (8 marks)
- b) If 66.5KJ are required to raise the temperature of 2.25kg of metal by 55°C , what is the specific heat capacity of the metal? (4 marks)

QUESTION 5

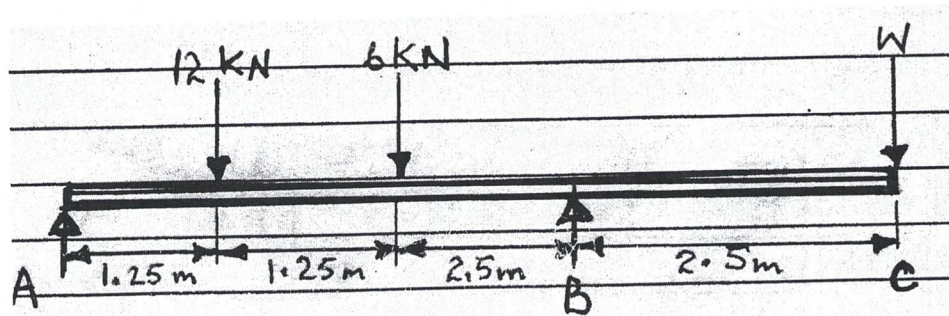
- a) A Toyota hilux truck hauls a trailer at 90km/hr when exerting a steady pull of 600N. Calculate:
- i) the work done in 30 minutes (3 marks)
 - ii) the power required (3 marks)
- b) A motor armature rotates at 1500 rev/min, has a gear A, with 30 teeth fixed to it.

This meshes with a gear B on another shaft which is required to rotate at 1000 rev/min,

Calculate the number of teeth on the second gear β (6 marks)

QUESTION 6

- a) Determine the magnitude and direction of the resultant of a force 30N acting horizontally to the right and a force of 40N, inclined at an angle of 60° to the 30N force. Use graphical method. (6 marks)
- b) A uniform beam ABC is 7.5m and rests horizontally on A and B supports which are 5m apart. Determine the load W applied at the ends C which will cause the beam to just lift off support A. (6 marks)



QUESTION 7

- a) Define the term 'indicated power' (2 marks)
- b) A four-cylinder, four stroke petrol engine whose cylinder bore is 90mm and stroke 120mm had the following observations after engine test was conducted.

Speed = 3000 rev/min

i.m.e.p = 900 KPa

Effective brake load = 210N at a radius of 0.8m

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|-----------|------|-----------------------|-----------|
| Determine | i) | Indicated power | (3 marks) |
| | ii) | Braking power | (3 marks) |
| | iii) | Friction power | (2 marks) |
| | iv) | Mechanical efficiency | (2 marks) |

QUESTION 8

A vehicle fitted with tyres having a running radius of 400mm is brought to rest in a distance of 80m from a speed of 55km/hr.

Calculate:

- i) Retardation of the vehicle
 - ii) Initial angular velocity of the wheels
 - iii) Angular retardation of the wheels
- (12 marks)

QUESTION 9

A car of mass 500kg is uniformly accelerated from rest for a distance of 100m up an inclined of 1 in 30.

If it's final velocity is 80km/h, calculate:

- a) the work done against gravity (3 marks)
- b) the change in kinetic energy (3 marks)
- c) the total work done by the car (3 marks)
- d) the tractive effort required (3 marks)

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