



ZIMBABWE

MINISTRY OF HIGHER AND TERTIARY EDUCATION

**HIGHER EDUCATION EXAMINATIONS COUNCIL
(HEXCO)**

NATIONAL CERTIFICATE

IN

**MOTOR MECHANICS, AUTOMOBILE ELECTRICS, DIESEL PLANT
FITTING, VEHICLE BODY REPAIR, PRECISION MACHINING AND
MOTOR CYCLE MECHANICS**

**SUBJECT: Engineering Science and
Mathematics**

PAPER NO: 346/S03

NOVEMBER 2011 EXAMINATION

REQUIREMENTS

INSTRUCTIONS TO CANDIDATE

1. SECTION A carries 10 marks. Answer ALL questions.
2. SECTION B carries 30 marks. Each question carries 6 marks.
Answer any five out of seven questions.
3. SECTION C carries 10 marks. Answer ALL questions.
4. SECTION D carries 50 marks. Each question carries 10 marks.
Answer any five out of eight questions.

This paper consists of 6 printed pages.

SECTION A

QUESTION 1

- 1.1 Determine the following product, giving the result in standard form.
 $(6.43 \times 10^3)(7.35 \times 10^4)$ (1 mark)
- 1.2 Factorise $x^2 + 3x - 10$ (1 mark)
- 1.3 Express the following in dinary form
 111.11_2 (1 mark)
- 1.4 In an electrical circuit the voltage V volts is given by $V = IR$. Find the voltage, when $I = 7.240$ amperes and $R = 12.57$ ohms, correct to 4 significant figures. (1 mark)
- 1.5 Solve the following equation for x
 $\lg x = 5$ (1 mark)
- 1.6 Integrate with respect to x
 $x^3 + 2x + 3$ (1 mark)
- 1.7 If $P = \begin{pmatrix} -1 & 2 \\ 3 & -4 \end{pmatrix}$ and $Q = \begin{pmatrix} 4 & 5 \\ 2 & 7 \end{pmatrix}$
Find $Q - P$ (1 mark)
- 1.8 Define a vector quantity. (1 mark)
- 1.9 Find the total surface area of a cone of radius 4.86cm and perpendicular height 10.58cm. (2 marks)

SECTION B**QUESTION 2**

- a) Solve the equation $\frac{4}{x-3} + \frac{2}{x} = \frac{6}{x-2}$ (6 marks)
- b) The simple interest, \$I on a sum of money, \$P after T years is given by formula $I = \frac{PRT}{100}$
- i) Make T the subject of formula. (3 marks)
- ii) Find T if $I = 51$, $P = 340$ and $R = 2 \frac{1}{2}$. (3 marks)
- c) i) If $y = 2x^2 - 5x + 3$, find $\frac{dy}{dx}$ and gradient at $x = 2$ (2 marks)
- ii) Find the equation of the tangent and normal at $y = 3x^3$ at point $(3, -3)$ (4 marks)
- d) i) $\int_0^1 (x^3 + x^{\frac{1}{2}} + 1) dx$ (3 marks)
- ii) Evaluate $[y^3]^{\frac{1}{2}}_{-\frac{3}{4}}$ (3 marks)
- e) A car travelling down the road increasing velocity from 8.9 m/s to 17.9 m/s in 20 sec. Calculate
- i) the distance travelled during this period. (3 marks)
- ii) the acceleration of the car. (3 marks)
- f) Use matrices to solve the following simultaneous equations
- $$\begin{aligned} 2x + 5y &= 1 \\ 3x - 2y &= 30 \end{aligned}$$
- (6 marks)
- g) Solve the indicial equation $x^{2.5} = 37.5$ correct to 4 significant figures. (6 marks)

SECTION C

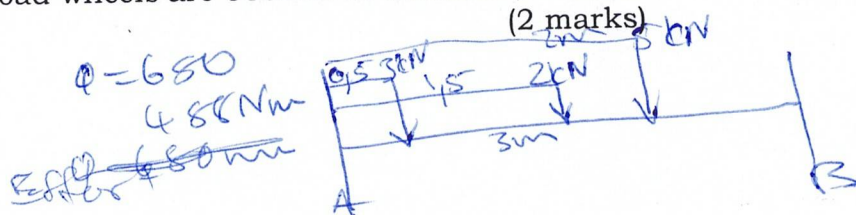
QUESTION 3

- A wheel rotating at 5 rad/s accelerates uniformly at 0.5 rad/s² for 30 sec
Find the angular velocity after the 30 sec (2 marks)
- State Newton's second law of motion. (1 mark)
- A steel brake rod is 1.25m long and when subjected to a pull, the extension produced is 0.5mm. Calculate the strain in the rod. (1 mark)
- Define the term Power. (1 mark)
- A vehicle is towed along a straight level road by a force of 120N. Calculate the work done in towing the vehicle through a distance of 70m. (1 mark)
- Briefly explain the term equilibrant. (1 mark)
- Complete the following
 $\beta = 2x - - - - -$ (1 mark)
- A torque of 484Nm exists in the axle shaft of the driving wheels of a motor vehicle. The road wheels are 680mm in diameter, what is the tractive effort? (2 marks)

SECTION D

QUESTION 4

A uniform beam AB, 3m long, is simply supported at its ends. The force due to gravity on the beam is 2kN and loads of 3kN and 5kN are placed on the beam at distances 0.5m and 2m respectively from end A. Where must an additional load of 2kN be placed to make the support reactions equal. (10 marks)



QUESTION 5

A steel brake rod is 1.2m long and is subjected to a maximum load of 4.5kN. If the extension of the rod is not to exceed 0.384mm, determine

- The maximum stress produced in the rod. (4 marks)
- Suitable diameter for the rod. (6 marks)

$$L = 1.2m$$

$$W = 4.5kN$$

$$x = 0.384mm$$

QUESTION 6

A single plate clutch of 0.15m effective diameter is lined with material of coefficient of friction 0.35. If the total spring force is 2.5kN, calculate

- a) Maximum torque transmitted. (5 marks)
- b) The power transmitted at 3 000rpm. (5 marks)

QUESTION 7

A steel component having a mass of 20 kg and a temperature of 700°C is dropped into a tank containing 40kg of water at 15°C. Neglecting the heat energy absorbed by tank and any loss of heat energy to the surrounding air, determine

- a) The final temperature of water. (7 marks)
- b) The heat energy absorbed by the water. (3 marks)

Take the specific heat capacities of steel and water as 0.48kJ/kgK and 4.2kJ/kgK respectively.

QUESTION 8

A flywheel of diameter 360mm increases its speed uniformly from 630rev/min to 1050 rev/min in 11 sec

Calculate:

- a) The angular acceleration of the wheel, in rad/s². (4 marks)
- b) The number of revolutions made during the speed change. (4 marks)
- c) The linear acceleration of a point on the rim of the wheel in m/s². (2 marks)

QUESTION 9

- a) In a gearbox the constant – mesh gears had 14 and 30 teeth, respectively. The low gear on the main shaft had 28 teeth and the meshing layshaft gear had 16 teeth. The engine speed was 2 000 rev/min and the road wheel diameter was 0.56m. Calculate the road speed of the vehicle in this low gear. (6 marks)
- b) A gearbox provides a reduction of 4 to 1. What torque acts on the output shaft when the input torque is 70 Nm (Neglect frictional losses. (4 marks)

QUESTION 10

$$VR = \frac{2\pi r}{L}$$

A screw jack has a 2 – start thread of 3mm pitch. An effort of 85N applied at a point 400mm along the handle is just sufficient to raise a mass of 800kg.

Calculate

- a) Torque on the handle in Nm. (3 marks)
- b) Velocity ratio of the jack. (3 marks)
- c) Mechanical advantage. (2 marks)
- d) Efficiency of the jack. (2 marks)

QUESTION 11

A single cylinder motor cycle engine has a connecting rod 120mm long and a stroke of 60mm.

Determine:

- a) Distance moved by piston from TDC when connecting rod reaches. Its maximum angularity relative to cylinder axis. (5 marks)
- b) The angle between the crank and connecting rod. (5 marks)

.....rg/wm