OCD004

UNIVERSITY OF BOLTON

OFF CAMPUS DIVISION

WESTERN INTERNATIONAL COLLEGE FZE

BENG(HONS) MECHANICAL ENGINEERING

TRIMESTER TWO EXAMINATION 2021/2022

ENGINEERING PRINCIPLES 2

MODULE NO: AME4063

Date: Tuesday 26th April 2022 **Time: 2:00pm – 4:00pm**

INSTRUCTIONS TO CANDIDATES: **There are SIX questions.**

Answer TWO Questions from Part A and TWO Questions from Part B.

All questions carry equal marks.

Marks for parts of questions are shown in brackets.

Electronic calculators may be used provided the data and program storage memory is cleaned prior to the examination.

CANDIDATES REQUIRE: **Formula Sheet (attached)**

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Engineering Principles 2
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PART A

Q1.

a) Differentiate the following given equations:

i. $y = 12\ln(2t^2 + 5)$

(3 marks)

ii. $y = \frac{2x}{x^2+1}$

(3 marks)

b) A particle moves in a straight line from a fixed point given by

$$\boldsymbol{x = 4t + \ln(1 - t)},$$

where '$\boldsymbol{x}$' is the distance travelled in meters and '$\boldsymbol{t}$' is the time taken in seconds. Determine,

i) The initial velocity and acceleration

(3 marks)

ii) The velocity and acceleration after 2.5 s

(4 marks)

c) An open rectangular container is to have a volume of 13.5m^3. Determine the least surface area of metal required for the manufacture of rectangular box.

(12 marks)

Total 25 marks

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Q2.

a) The potential difference between boundaries **a** and **b** of an electric field is given by:

$$V = \int_a^b \frac{Q}{2\pi r \varepsilon_0 \varepsilon_r} dr$$

If a = 10, b = 20, Q = 2 x 10^{-6} coulombs, ε_0 = 8.85 x 10^{-12} ε_r = 2.77.

Determine the potential difference (V) in volts integrating with respect to the radial distance r.

(7 marks)

b) The average value of a complex voltage waveform is given by:

$$V_{AV} = \frac{1}{\pi} \int_0^{\pi} (10 \, sin \, \omega t \; + 3 \, sin \, 3\omega t \; + \; 2 \, sin \, 5\omega t \,) d(\omega t)$$

Where ω is the angular velocity in rad/sec

Evaluate V_{AV} correct to 2 decimal places.

(8 marks)

c) Evaluate the following given equations:

I. $\int_0^1 3e^{3t} dt$

(3 marks)

II. $\int_{\frac{\pi}{4}}^{\frac{\pi}{2}} (3 \, sin2x - 2 \, cos3x) dx$

(4 marks)

III. $\int \frac{(2+3x)^2}{\sqrt{x}} \mathrm{d}x$

(3 marks)

Total 25 marks

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Q3.

a) Determine the particular solution of angular displacement θ *(deg)*, given that it follows the equation,

$$2t\left(t - \frac{d\theta}{dt}\right) = 5$$

Given that, when time t = 0, $\theta = 0$

(9 marks)

b) The rate of cooling of a body is given by,

$$\frac{d\theta}{dt} = k\theta$$, where k is a constant.

When $\theta = 60^0$C, at t = 2 minutes and $\theta = 50^0$C, at t = 5 minutes.

i. Deduce a general solution for the above first order differential equation.

(10 marks)

ii. Determine the time taken to fall to 40^0C, correct to the nearest second.

(6 marks)

Total 25 mark

END OF PART A

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PART B

Q4. **Figure Q4** is a section with the dimensions in cms as shown. Determine the following:

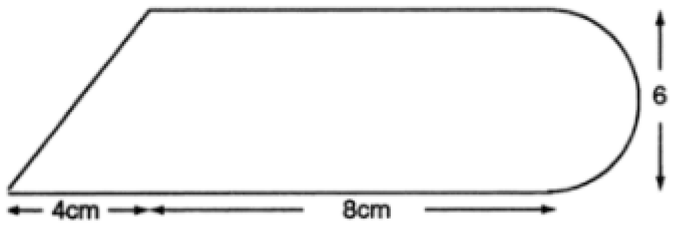

Figure Q4. section

i. the centroid of the section

(10 marks)

ii. the moment of inertia of the section about the 'xx' axis through the centroid.

(6 marks)

iii. the moment of inertia of the section about the 'yy' axis through the centroid.

(6 marks)

iv. the radius of gyration

(3 marks)

Total 25 marks

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Q5 a) A hollow steel shaft transmits 200kW of power at 150rpm.The total angle of twist in a length of 5m of the shaft is 4^o . The permissible shear stress is 70MPa and the modulus of rigidity of the material is 90 GPa.

Determine the following:

i. the inner diameter of the shaft

(4 marks)

ii. the outer diameter of the shaft

(4 marks)

iii. Differentiate between polar moment of inertia of solid and hollow shafts.

(2 marks)

iv. Define Torsion and Bending equation

(2 marks)

b) A spring loaded with 5kg weight is extended 650mm when in equilibrium. The mass is pulled vertically downward through a further distance of 300mm and is then released from rest so that it oscillates about the equilibrium position. Determine :

i. the stiffness constant 'k' of the spring and time of oscillation in seconds

(4 marks)

ii. the velocity and acceleration when the weight is at a distance of 100mm below its equilibrium position.

(4 marks)

c) A car weighing 8000N accelerates from rest to a speed of 45km/h in a distance of 50m against a resistance of 100N.Determine the average driving force acting on the car. Using the average force, evaluate the greatest power developed by the engine.

(5 marks)

Total 25 marks

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Q6. a) Define the following terms:

i) coefficient of friction

(3 marks)

ii) angle of friction

(3 marks)

iii) angle of repose

(3 marks)

b) A body requires a pull of 30N and a push of 36N to just move it over a rough horizontal plane. Both the pull and the push are inclined at 25^{o} with the horizontal as shown in **Figure Q6b**.Compute the following:

i) Weight of the body.

(8 marks)

ii) Coefficient of friction

(8 marks)

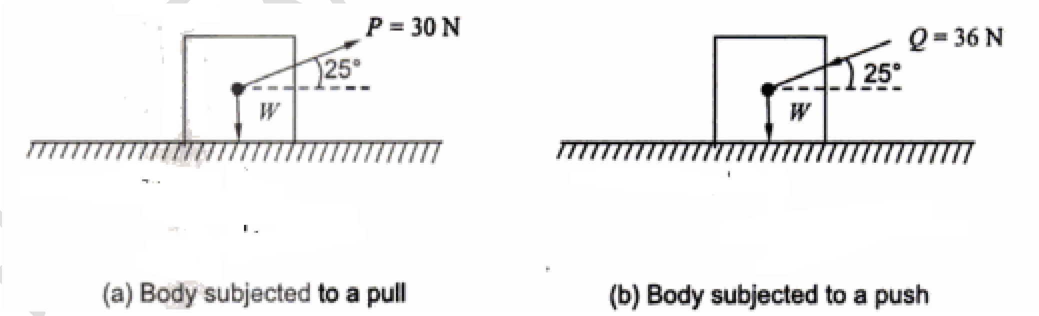

Figure Q6b. Given block

Total 25 marks

END OF QUESTIONS

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FORMULA SHEET

Vectors

$\underline{A} \cdot \underline{B} = |\underline{A}||\underline{B}|\cos\theta$

Determinants

$$\frac{x}{D_x} = \frac{-y}{D_y} = \frac{z}{D_z} = \frac{-1}{D}$$

Matrices

$$A^{-1} = \frac{adjA}{D}$$

$$X = A^{-1}B$$

Series

$U_n = a + (n - 1)\, d$

$S_n = \frac{n}{2}[2a + (n - 1)\, d]$

$U_n = ar^{n-1}$

$S_n = \frac{a(1-r^n)}{1-r}$

$S_\infty = \frac{a}{1-r}$

$U_n = a + (n - 1)d + \frac{1}{2}(n - 1)(n - 2)C$

Binomial Distribution

$$(q+p)^n = q^n + n\,q^{n-1}\,p + \frac{n(n-1)}{2!}q^{n-2}\,p^2 + \frac{n(n-1)(n-2)}{3!}\,q^{n-3}\,p^3 + \cdots$$

Partial Fractions

$$\frac{F(x)}{(x+a)(x+b)} = \frac{A}{(x+a)} + \frac{B}{(x+b)}$$

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$$\frac{F(x)}{(x+a)(x+b)^2} = \frac{A}{(x+a)} + \frac{B}{(x+b)} + \frac{C}{(x+b)^2}$$

Trigonometry

$\sin 2x = 2 \sin x \cos x$

$\cos 2x = \cos^2 x - \sin^2 x$

$\cos 2x = 2\cos^2 x - 1$

$\cos 2x = 1 - 2\sin^2 x$

$\tan 2x = \dfrac{2\tan x}{1-\tan^2 x}$

$\sin^2 x + \cos^2 x = 1$

$\tan^2 x + 1 = \sec^2 x$

$\operatorname{cosec}^2 x = 1 + \cot^2 x$

Differentiation

$y = uv \qquad \dfrac{dy}{dx} = u\dfrac{dv}{dx} + v\dfrac{du}{dx}$ (Product Rule)

$y = \dfrac{u}{v} \qquad \dfrac{dy}{dx} = \dfrac{v\dfrac{du}{dx} - u\dfrac{dv}{dx}}{v^2}$ (Quotient Rule)

$\dfrac{dy}{dx} = \dfrac{dy}{dt} \times \dfrac{dt}{dx}$ (Chain Rule)

Integration

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$$\int u \frac{dv}{dx} dx = uv - \int v \frac{du}{dx} dx \quad \text{(By parts)}$$

$$\int \frac{f^1(x)}{f(x)} dx = \ln |f(x)| + c$$

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Differential equations

Linear differential equation

$dy/dx + Py = Q$

Integrating factor is $e^{\int P dx}$

Solution is $y \times IF = \int Q \times IF dx$

Centroid and 2nd Moments of Area

Rectangle $\bar{X} = (b/2)$, $\bar{Y} = (d/2)$, $A = bd$ $\quad I_{XX} = \frac{bd^3}{12}$ $\quad I_{YY} = \frac{db^3}{12}$

Circle $I_{XX} = \frac{\pi R^4}{4}$ $\quad$ Polar $J_{solid} = \frac{\pi D^4}{32}$ $\quad J_{hollow} = \pi(D^4 - d^4)/32$

For composite sections

$$\bar{X} = \frac{\Sigma A i X i}{\Sigma A i}$$

$$\bar{Y} = \frac{\Sigma A i Y i}{\Sigma A i}$$

Parallel Axis Theorem

$I_{xx} = I_{GG} + Ah^2$

$I_{XX} = (I_{XX})_i + \Sigma A_i (Y_i - \overline{Y})^2$

$I_{YY} = (I_{YY})_i + \Sigma A_i (X_i - \overline{X})^2$

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Energy and Momentum

Potential Energy = mgh

Kinetic Energy

Linear = ½ mv^2

Angular=½ $I\omega^2$

Momentum

Linear= mv

Angular= $I\omega$

Vibrations

Linear Stiffness $k = \dfrac{F}{\delta}$

Circular frequency $\omega_n = \sqrt{\dfrac{k}{m}}$

Frequency $f_n = \dfrac{\omega_n}{2\pi} = \dfrac{1}{T_n}$

$x = r\cos\omega t$

$v = -\omega\sqrt{r^2 - x^2} = -\omega r \sin\omega t$

$a = -\omega^2 x$

$f = \frac{1}{T}$

$T = \frac{2\pi}{\omega}$

M/I $= \sigma/y$ =E/R

P= 2πNT

T/J =$G\theta/L$ =τ/r

F=μ N

END OF FORMULA SHEETS

END OF PAPER