UNIVERSITY OF BOLTON

WESTERN INTERNATIONAL COLLEGE FZE

BENG (HONS) MECHANICAL ENGINEERING

SEMESTER TWO EXAMINATION 2018/2019

ENGINEERING PRINCIPLES 2

MODULE NO: AME4063

Date: Wednesday 22nd May 2019 **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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PART A

Q1.

a) Differentiate the following questions:

i) $y = ln\sqrt{x^2 - 1}$ (4 marks)

ii) $y = \sqrt{x^3}\ln 3x$ (3 marks)

b) A particle move 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 (4 marks)

ii) The velocity and acceleration after 1.5 s (4 marks)

c) A can manufacturing company requires to maximize the volume of a can using a given surface area of metal sheet. The surface area of the can including the top and bottom surfaces is 400cm^2. Determine the Height (H) in cm and Radius (R) in cm so that the volume is maximum.

(10 marks)

(Total 25 marks)

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Q2.

a) Integrate the following:

i) $\int_0^2 x\sqrt{(2x^2+1)}\,dx$ (3 marks)

ii) $\int 2\,cot^2 2t$ (3 marks)

b) A tank of water is in the shape of a cone of height 20 meters and radius of 8 meters. If the tank is filled with water how much work is required to pump all of the water to the top of the tank. Assume that the density of water is 1000 kg/m^3.

(13 marks)

c) An automatic machine produces, on average, 97% of its components to be of within the tolerance required. In a sample of ten components from this machine, determine the probability of having

i) fewer than two components outside of the tolerance required.

(3 marks)

ii) more than two items be defective, assuming a binomial distribution.

(3 marks)

(Total 25 mark)

Q3.

a) The differential equation relating the Tension **T**, contact angle $\boldsymbol{\theta}$ and Coefficient of friction **μ** is given by

$$\frac{dT}{d\theta} = \mu T$$

If $\theta = 0$ when $T = 150$ N and $\mu = 0.30$.

Determine,

i) Tension (T) at the point of slipping when $\theta = 2$ radians (7 marks)

ii) Contact angle (θ) when the tension $T = 300$N (8 marks)

b) Determine the particular solution of angular displacement θ, given that it follows the equation,

$$\frac{d\theta}{dt} = 2e^{3t-2\theta}$$

Given that, when time $t = 0$, $\theta = 0$ (10 marks)

(Total 25 marks)

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PART B

Q4.

A rolled steel joist of I section has the dimensions as shown in Figure Q4. Determine the following:

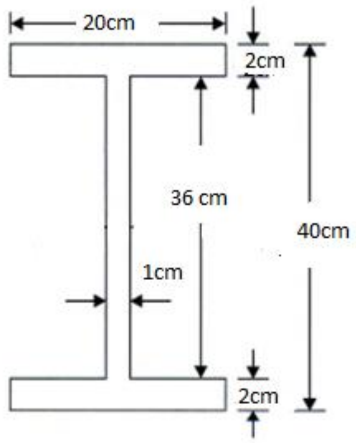

Figure Q4. I section

i. the centroid of the section (7 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)

v. If this beam of I section carries a uniformly distributed load of 40kN/m rum on a span of 10m, find maximum stress produced due to bending in xx and yy direction. (3 marks)

Total 25 marks

Please turn the page

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 3^{o} . The permissible shear stress is 60MPa and the modulus of rigidity of the material is 80 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 4kg weight is extended 600mm when in equilibrium. The mass is pulled vertically downward through a further distance of 280mm 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 120mm below its equilibrium position. (4 marks)

c) A car with wheel diameter 75cm is running at 72kmph. The car is brought to rest with uniform retardation and it covers 20 metres. Calculate the angular velocity of wheel about its axis of rotation.Also determine the angular retardation of the wheel. (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)

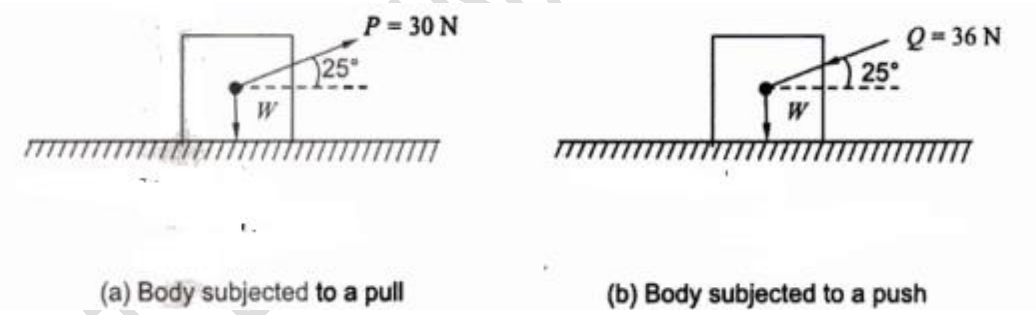

Figure Q6b. Given block

Total 25 marks

END OF QUESTIONS

Formula sheet starts over the page

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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

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

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Partial Fractions

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

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

Trigonometry

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

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

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

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

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

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

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

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

Differentiation

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

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

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

Integration

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

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

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 $I_{XX} = \frac{bd^3}{12}$ $I_{YY} = \frac{db^3}{12}$

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

For composite sections

$$\bar{X} = \frac{\Sigma AiXi}{\Sigma Ai}$$

$$\bar{Y} = \frac{\Sigma AiYi}{\Sigma Ai}$$

Parallel Axis Theorem

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

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

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

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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 $k = \frac{F}{\delta}$

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

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

$$x = r\cos\omega t$$

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

$$a = -\omega^2 x$$

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

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

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

P= $2\pi NT$

T/J $= G\theta/L$ $=\tau/r$

F=μ N

END OF FORMULA SHEET