UNIVERSITY OF BOLTON

OFF-CAMPUS DIVISION

BACHELOR OF ENGINEERING (HONOURS) IN MECHANICAL ENGINEERING

MALAYSIA - KTG

SEMESTER 1 EXAMINATION 2018/2019

ENGINEERING PRINCIPLES 2

MODULE NO: AME 4053

Date: Monday 7th January 2019 **Time: 2 Hours**

INSTRUCTIONS TO CANDIDATES:

There are FOUR questions.

Answer ALL questions.

All questions carry equal marks.

Marks for parts of questions are shown in brackets.

This examination paper carries a total of 100 marks.

All working must be shown. A numerical solution to a question obtained by programming an electronic calculator will not be accepted.

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Q1. (a) An car is uniformly accelerated from rest for 600 m, runs 900 m at the maximum speed attained and is then brought to rest at the next station. The distance between stations is 4 km and the total time taken is 170 s. Calculate the maximum speed attained. (10 marks)

(b) A chipping machine is designed to eject wood chips at an initial velocity of 30 m/s at 30 m above the ground. If the tube is oriented at 50° from the horizontal, identify the maximum attainable height of the chips, total time of flight, and the distance from the foot of the machine to the point where the chips strikes to the ground. (15 marks)

Total 25 marks

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Q2. A rolled steel of a section has the dimension as shown in Figure Q2. Evaluate the following:

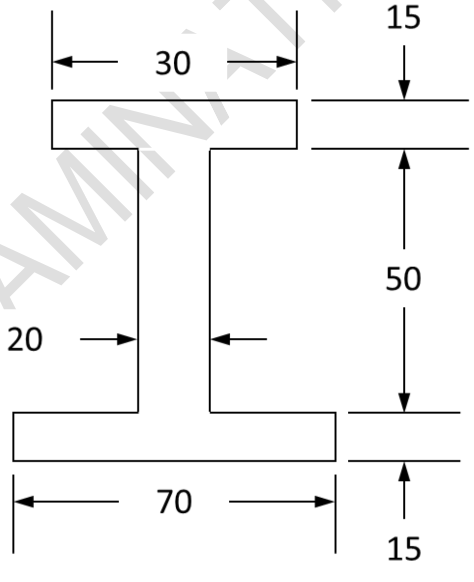
(a) The centroid of the section. (7 marks)

(b) The moment of inertia of the section about xx-axis through the centroid. (6 marks)

(c) The moment of inertia of the section about yy-axis through the centroid. (6 marks)

(d) The radius of gyration in xx and yy directions. (3 marks)

(e) If this beam with this section carries a positive bending moment of 60 Nm, find the maximum stress produced due to bending. (3 marks)



All dimensions in mm.

Figure Q2

Total 25 marks

Please turn the page

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Q3. Integrate:

(a) $\int xe^{-2x}\,dx$ (4 marks)

(b) $\int_0^4 \sqrt{16-x}\,dx$ (5 marks)

(c) $\int_3^5 \frac{2x-6}{x^2+x-6}\,dx$ (7 marks)

(d) $\int \frac{1}{\sqrt{9-4x^2}}\,dx$ (9 marks)

Total 25 marks

Please turn the page

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Q4. (a) Show that the integrating factor for the ordinary differential equation:

$$\frac{dy}{dx} + \left(-\frac{1}{x} + 2x\right) y = \frac{2x^2 e^{-x^2}}{1 + x^2}$$

is $x^{-1} e^{x^2}$.

(4 marks)

Hence find the general solution to this equation. Find also the specific solution such that $y(1) = 0$. (6 marks)

(b) Find the general solution of each of the following ordinary differential equation:

(i) $\frac{d^2y}{dx^2} - 4\frac{dy}{dx} + 13y = 0$ (2 marks)

(ii) $2\frac{d^2y}{dx^2} - \frac{dy}{dx} - y = 0$ (2 marks)

(iii) $\frac{d^2y}{dx^2} - 4\frac{dy}{dx} + 4y = 0$ (2 marks)

(c) Show that the differential equation:

$$ye^x - 2x + y + \frac{1}{x^2} + \left(e^x - x + 2y + \frac{1}{x}\right)\frac{dy}{dx} = 0$$

is exact, and find its general solution in the form $F(x, y) = c$, where c is an arbitrary constant and $F(x, y)$ is a function which you should identify. (9 marks)

Total 25 marks

END OF QUESTIONS

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Formula Sheet

1. Stress and Strain

$$\sigma = \frac{F}{A}$$

$$\varepsilon = \frac{u}{L}$$

$$E = \frac{\sigma}{\varepsilon}$$

$$\tau = \frac{F}{A}$$

$\gamma =$ shear strain

$$\nu = -\frac{\varepsilon_{lat}}{\varepsilon_{long}}$$

$$G = \frac{\tau}{\gamma}$$

$$\varepsilon_{lat} = -\nu\frac{\sigma_{long}}{E}$$

$$\varepsilon_{valumetric} = \frac{\delta V}{V}$$

$$K = \frac{\sigma}{\delta V/V}$$

$$\varepsilon_x = \frac{\sigma_x}{E} - \nu\frac{\sigma_y}{E} - \nu\frac{\sigma_z}{E}$$

$$\varepsilon_y = \frac{\sigma_y}{E} - \nu\frac{\sigma_x}{E} \ldots \text{etc}$$

$$\varepsilon_z = \frac{\sigma_z}{E} \ldots \text{etc}$$

$$K = \frac{E}{3(1-2\nu)}$$

$$G = \frac{E}{2(1+\nu)}$$

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2. Static Equilibrium

$$\sum F_x = 0 \qquad \sum F_y = 0 \qquad \sum F_z = 0$$

$$\sum M_x = 0 \qquad \sum M_y = 0 \qquad \sum M_z = 0$$

3. Thin Pressure Vessels

$$\sigma_{hoop} = \frac{pd}{2t}$$

$$\sigma_{longitudinal} = \frac{pd}{4t}$$

$$\delta_{longitudinal} = \frac{pd}{4tE}(1 - 2\nu)l$$

$$\delta_{diametral} = \frac{p}{4tE}(1 - \nu)d^2$$

4. For Cylindrical Shells

$$\delta V = \frac{pd}{4tE}(5 - 4\nu)V$$

5. For Spherical Shells

$$\delta V = \frac{3pd}{4tE}(1 - \nu)V$$

6. Second Moment of Area

Rectangle	Circle	Polar
$I = \frac{bd^3}{12}$	$I = \frac{\pi d^4}{64}$	$J = \frac{\pi d^4}{32}$

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7. Parallel Axis Theorem

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

8. Bending

$$\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R}$$

9. Torsion

$$\frac{T}{J} = \frac{\tau}{r} = \frac{G\vartheta}{\lambda}$$

10. Motion

$$v = u + at \qquad \omega_2 = \omega_1 + \alpha t$$

$$v^2 = u^2 + 2as \qquad \omega_2^2 = \omega_1^2 + 2\alpha\vartheta$$

$$s = \left(\frac{u+v}{2}\right)t \qquad \vartheta = \left(\frac{\omega_1 + \omega_2}{2}\right)t$$

$$s = ut + \frac{1}{2}at^2 \qquad \vartheta = \omega_1 t + \frac{1}{2}at^2$$

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}} \qquad \text{Acceleration} = \frac{Velocity}{Time}$$

$$s = r\vartheta$$

$$V = \omega r$$

$$a = \alpha r$$

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11. Torque and Angular

$T = I\alpha$
$I = mk^2$
$P = T\omega$

12. Energy and Momentum

$\text{Potential energy} = mgh$
$\text{Linear kinetic energy} = \frac{1}{2}mv^2$
$\text{Angular kinetic energy} = \frac{1}{2}I\omega^2$
$\text{Linear momentum} = mv$
$\text{Angular momentum} = I\omega$

13. Vibration

$k = \frac{F}{\delta}$ $\omega_n = \sqrt{\frac{k}{m}}$ $f_n = \frac{\omega_n}{2\pi} = \frac{1}{T_n}$

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

$F = ma$

14. Integration

$$\int x^n\,dx = \frac{x^{n+1}}{n+1} + C, n \neq -1$$
$$\int (ax+b)^n\,dx = \frac{(ax+b)^{n+1}}{a(n+1)} + C, n \neq -1$$
$$\int \frac{1}{x}\,dx = \ln|x| + C$$
$$\int \frac{1}{ax+b}\,dx = \frac{1}{a}\ln|ax+b| + C$$
$$\int e^x\,dx = e^x + C$$
$$\int e^{mx}\,dx = \frac{1}{m}e^{mx} + C$$

$$\int \cos x \, dx = \sin x + C$$
$$\int \cos nx \, dx = \frac{1}{n} \sin x + C$$
$$\int \sin x \, dx = -\cos x + C$$
$$\int \sin nx \, dx = -\frac{1}{n} \cos x + C$$
$$\int \sec^2 x \, dx = \tan x + C$$
$$\int \sec^2 nx \, dx = \frac{1}{n} \tan x + C$$
$$\int \frac{1}{\sqrt{1 - x^2}} dx = \sin^{-1} x + C$$
$$\int \frac{1}{\sqrt{a^2 - x^2}} dx = \sin^{-1} \left(\frac{x}{a}\right) + C$$
$$\int \frac{1}{1 + x^2} dx = \tan^{-1} x + C$$
$$\int \frac{1}{a^2 + x^2} dx = \frac{x}{a} \tan^{-1} \left(\frac{x}{a}\right) + C$$
$$\int u \frac{dv}{dx} dx = uv - \int v \frac{du}{dx} dx$$

15. Common Functions and Their Derivatives

In this table k, n, and c are constants.

Function	**Derivative**
Constant	0
x	1
kx	k
x^n	nx^{n-1}
kx^n	knx^{n-1}
e^x	e^x
e^{kx}	ke^{kx}
$\ln x$	$\frac{1}{x}$

$\ln kx$	$\frac{1}{x}$
$\sin kx$	$k\cos kx$
$\sin(kx + C)$	$k\cos(kx + C)$
$\cos x$	$-\sin x$
$\cos kx$	$-k\sin kx$
$\cos(kx + C)$	$-k\sin(kx + C)$
$\tan x$	$\sec^2 x$
$\tan kx$	$k\sec^2 x$
$\tan(kx + C)$	$k\sec^2(kx + C)$

Recall that in the following:

$$y' = \frac{dy}{dx} \qquad f' = \frac{df}{dx} \qquad g' = \frac{dg}{dx}$$

Product rule:

$$y = f(x) \cdot g(x)$$

$$y' = f'(x) \cdot g(x) + f(x) \cdot g'(x)$$

Quotient rule:

$$y = \frac{f(x)}{g(x)}$$

$$y' = \frac{f'(x) \cdot g(x) + f(x) \cdot g'(x)}{g(x)^2}$$

Chain rule:

$$y = f[g(x)]$$

$$y' = f'[g(x)] \cdot g'(x)$$

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16. Differential Equations

Auxillary equations for differential equations of the form:

$$a\frac{d^{2y}}{dx^2} + b\frac{dy}{dx} + cy = 0$$

(a) Real and different roots α and β:
$y = Ae^{\alpha x} + Be^{\beta x}$

(b) Repeated (real and equal) and different roots α and β:
$y = e^{\alpha x}(A + Bx)$

(c) Complex roots $(p \pm iq)$:
$y = Ae^{\alpha x} + Be^{\beta x}$

17. Numerical Methods

Approximating integrals:

(a) For trapezoidal rule:
$$\int_{x=a}^{b} f(x)\,dx \approx \frac{h}{2}[y_0 + (y_1 + y_2 + y_3 + \cdots + y_{n-1}) + y_n]$$

(b) For Simpson's rule:
$$\int_{x=a}^{b} f(x)\,dx \approx \frac{h}{3}[y_0 + (4y_1 + 2y_2 + 4y_3 + \cdots + 4y_{n-1}) + y_n]$$

where $h = (b - a)/n$ is the step size and n indicates the number of strips.
(Note: for Simpson's rule, n must be even)

Root finding:

For function $f(x)$, the solutions to $f(x) = 0$ can be found using the following iterative scheme:

$$x_{i+1} = x_i - \frac{f(x_i)}{f'(x_i)}$$

This is the Newton-Raphson method.