UNIVERSITY OF JOHANNESBURG

PROGRAM	:	NATIONAL DIPLOMA *ENGINEERING: MECHANICAL*
SUBJECT	:	**MECHANICS OF MACHINES III**
CODE	:	**EMM313**
DATE	:	MID-YEAR SUPPLEMENTARY EXAMINATION 19 JULY 2019
DURATION	:	(X-PAPER) 08:00 - 11:00
WEITHT	:	40 :60
FULL MARKS	:	90
TOTAL MARKS	:	96

EXAMINER	:	MR P STACHELHAUS	081912603
MODERATOR	:	DR T LASEINDE	2187
NUMBER OF PAGES	:	4 PAGES AND 1 ANNEXURE	

INSTRUCTIONS:

- AN A3 DRAWING BOARD OR DRAFTING HEAD MAY BE USED.
- A CALCULATOR OF ANY MAKE OR MODEL IS PERMITTED.

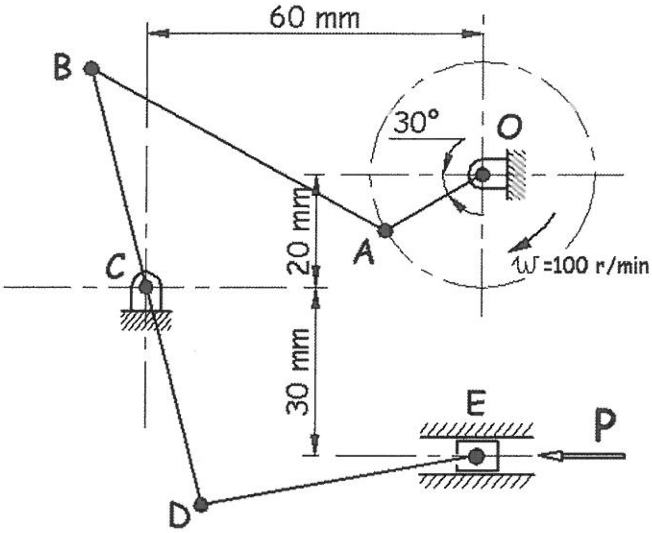
REQUIREMENTS:

- 1 SHEET OF A3 DRAWING PAPER

INSTRUCTIONS TO STUDENTS:

- IT WILL BE EXPECTED THAT THE STUDENT MAKES REASONABLE ASSUMPTIONS FOR DATA NOT SUPPLIED.
- NUMBER YOUR QUESTIONS CLEARLY AND UNDERLINE THE FINAL ANSWER.
- ANSWERS WITHOUT UNITS WILL BE IGNORED.
- ALL DIMENSIONS ON DIAGRAMS ARE IN mm UNLESS OTHERWISE SPECIFIED.

QUESTION 1



LINKAGE LENGTHS

OA = 20 mm

AB = 60 mm

BC = CD = 40 mm

DE = 50 mm

In the figure above, the crank rotates uniformly in a clockwise direction at a speed of 100 r/min, supplying a torque of 8 Nm. Rod BCD is symmetrical. When OA is 30° below the horizontal as shown:

1.1	Construct a configuration diagram using a scale 1:1;	(4)
1.2	Construct a velocity diagram using a scale 200 mm = 1 m/s; and	(6)
1.3	Construct an acceleration diagram to a scales of 20 mm = 1 m/s^2	(10)
1.4	Determine the velocity and direction of piston E.	(1)
1.5	Determine the acceleration and direction of piston E.	(1)
1.6	Determine the forces acting through bearings O and C and force P.	(7)
1.7	Determine the maximum bending moment in rod BCD.	(3)
1.8	Determine the Kinetic Energy of the rod BCD if its mass is 0.6 kg and Radius of Gyration is 25 mm.	(3)

[35]

QUESTION 2

A single cylinder horizontal steam engine has a stroke of 0.75 m and a connecting rod 1.8 m long. The mass of the reciprocating parts is 520 kg and that of the connecting rod is 230 kg. The centre of gravity of the rod is 0.8 m from the crankpin and the moment of inertia about an axis through the small end of the rod is 360 kgm^2. For an engine speed of 90 r/min and a crank position of 45° from the top dead centre, determine:

2.1 the torque on the crankshaft due to the inertia forces; (8)

2.2 the total kinetic energy of the Connecting-Rod. (4)

[12]

QUESTION 3

The following details refer to a lift:

Mass of car:	800	kg
Mass of ropes including balance ropes	300	kg
Mass of counterweight	1 140	kg
Maximum number of passengers	12	
Average mass of passengers	75	kg
Driving sheave diameter	1.25	m
Friction torque acting on sheave	1000	Nm
Maximum car speed	2.5	m/s

Calculate the maximum torque if the lift accelerates a full load with uniform acceleration to full speed within three seconds from the lowest landing, then travels at constant speed for 30 seconds, brings the load to rest with a retardation of 1.1 m/s^2 at the upper landing and then stands stationary for 10 seconds.

[11]

QUESTION 4

The engine of a car rotates at 12 times the speed of the road wheels, which are 500 mm in diameter. The mass of the car and driver is 650 kg. The rotating parts at the engine are equivalent to a mass of 10 kg at a radius of gyration of 125 mm. The rotating parts at the wheels are equivalent to a mass of 100 kg at a radius of gyration of 300 mm. The resistance to motion of the car is 800 N. Take the efficiency of power transmission as 86%. If the car is climbing a hill of gradient 1 in 40 with an acceleration of 0.6 m/s^2, determine the engine torque and power at the instant the velocity of the car is 6 m/s.

[14]

QUESTION 5

5.1 Derive an equation, from first principles, for the torque that can be transmitted by a new cone-clutch, in terms of the axial thrust F and any other variables you may require.

(6)

5.2 A multi-plate clutch is to transmit 7.5 kW at 1 440 r/min. The inner and outer diameters of the contact surfaces are 105 mm and 150 mm respectively. The clutch linings are to be manufactured from a material that has a maximum allowable pressure of 150 kPa and coefficient of friction of 0.3. Assume conditions of uniform wear and determine:

5.2.1 the minimum number of clutch plates. (7)

5.2.2 the contact pressure at the inner and outer radii. (7)

[20]

QUESTION 6

Describe whether the friction force between two solid objects is dependant on the area of contact and substantiate your answer with examples.

[4]

TOTAL : 96

ANNEXURE

FORMULA SHEET

1. Crank and connecting rod mechanism

$$x = r\left(1 - \cos\theta + \frac{\sin^2\theta}{2n}\right) \qquad \phi = \sin^{-1}\left[\frac{\sin\theta}{n}\right]$$

$$v = \omega r\left(\sin\theta + \frac{\sin 2\theta}{2n}\right) \qquad \Omega = \frac{\omega\cos\theta}{n\cos\phi}$$

$$f = \omega^2 r\left(\cos\theta + \frac{\cos 2\theta}{n}\right) \qquad \alpha \cong \frac{\omega^2\sin\theta}{n}$$

$$N = \frac{m\left(ab - k^2\right)\alpha}{l\cos\phi} \qquad n = \frac{l}{r}$$

$$m_1 = \frac{b}{l}m \qquad m_2 = \frac{a}{l}m$$

$$F = pa - R\omega^2 r\left(\cos\theta + \frac{\cos 2\theta}{n}\right) + Rg$$

$$I_G = mk^2 \qquad K.E. = \frac{1}{2}I_G\Omega^2$$

2. General use formulae

$$\cos(2\theta) = \cos^2\theta - \sin^2\theta = 2\cos^2\theta - 1 = 1 - 2\sin^2\theta$$
$$\sin(2\theta) = 2\sin\theta\cos\theta$$
$$\cos(\alpha \pm \beta) = \cos\alpha\cos\beta \mp \sin\alpha\sin\beta$$
$$\sin(\alpha \pm \beta) = \sin\alpha\cos\beta \pm \cos\alpha\sin\beta$$
$$(1+x)^n = 1 + nx + \frac{n(n-1)x^2}{2!} + \frac{n(n-1)(n-2)x^3}{3!} + \ldots\ldots$$

3. Friction clutches

Uniform pressure	Uniform wear
$F = \pi p\left(r_1^2 - r_2^2\right)$	$F = 2\pi pr(r_1 - r_2)$
$T = \frac{2}{3}\mu F\left(\frac{r_1^3 - r_2^3}{r_1^2 - r_2^2}\right)n$	$T = \mu FRn$
$T = \frac{2}{3}\pi\mu p\left(r_1^3 - r_2^3\right)n$	$T = \pi\mu pr\left(r_1^2 - r_2^2\right)n$

4. General dynamics

- Equivalent mass of a rotating body: $m_e = m\left(\frac{k}{r}\right)^2$ and $F = m_e a$
- Acceleration of geared systems assuming a 100% efficiency:

equivalent moment of inertia $= I_a + n^2 I_b$

$T_{b\text{ to accelerate }b} = I_b n\alpha_a \qquad T_{a\text{ to accelerate }b} = n^2 I_b\alpha_a$

$T_{a\text{ to accelerate }a} = I_a\alpha_a \qquad T_{a\text{ to accelerate }a\text{ and }b} = \left(I_a + n^2 I_b\right)\alpha_a$