UNIVERSITY OF JOHANNESBURG

PROGRAM	:	NATIONAL DIPLOMA ENGINEERING: MECHANICAL
SUBJECT	:	**MECHANICS OF MACHINES 3**
CODE	:	**EMM313**
DATE	:	SSA EXAMINATION 18 JULY 2014
DURATION	:	(SESSION 1) 08:00 - 11:00
WEIGHT	:	40 : 60
TOTAL MARKS	:	100

ASSESSOR	:	DR L MTHEMBU
MODERATOR	:	MS D IONESCU
NUMBER OF PAGES	:	4 PAGES + 1 ANNEXTURE

2187

INSTRUCTIONS

- AN A3 PORTABLE DRWAING BOARD MAY BE USED.
- A CALCULATOR OF ANY MAKE OR MODEL IS PERMITTED.
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INSTRUCTIONS TO STUDENTS:

- ANSWER ALL QUESTIONS.
- A STUDENT IS EXPECTED TO MAKE 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.

REQUIREMENTS:

- 1 SHEET OF A3 DRAWING PAPER.

QUESTION 1

A mechanism is shown in figure 1 below. The crank AC is in the given position and is rotating clockwise at 300 r/min. The lengths of the links are as shown in figure 1.

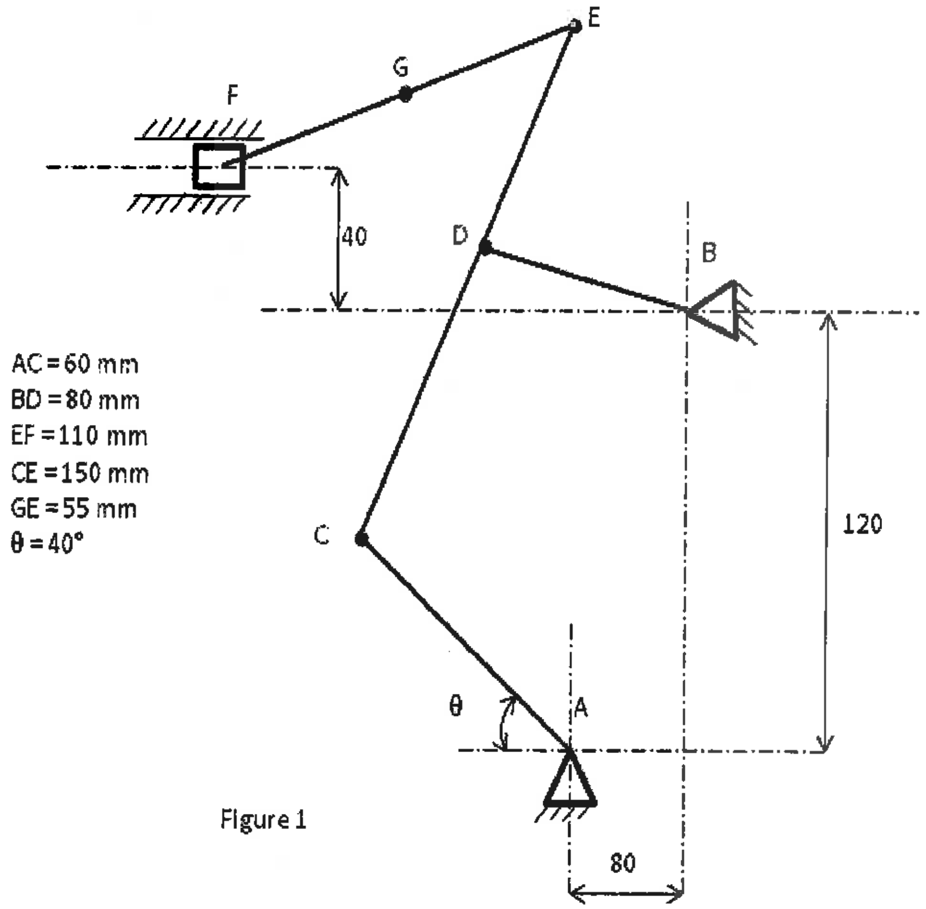

Figure 1

1.1. Draw the configuration diagram at a scale of 1:1. (5)
1.2. Draw a velocity diagram at a scale of 1 mm = 0.0125 m/s. (8)
1.3. Determine the velocity of the slider F. (2)
1.4. Calculate the rubbing velocity of E if the pin diameter is 35 mm. (5)
1.5. Determine the kinetic energy of the connecting rod EF if it has a mass of 2.0 kg and its radius of gyration about the centre of gravity G is 32 mm. (6)
1.6. If a force of 400 N is applied to the slider in the direction of its motion, calculate the torque produced at A. Neglect any loss of energy. (2)

[28]

QUESTION 2

A vertical engine has a stroke of 500 mm and a cylinder diameter of 200 mm. The piston rod diameter is 50 mm and the connecting rod has a length of 1050 mm. The reciprocating parts have a mass of 110 kg. When the crank is 60° from the top dead centre position, the gauge gas pressure on the top side of the piston is 530 kN/m^2 and on the underside is 160 kN/m^2. Neglecting the inertia forces; calculate:

2.1. The force in the connecting rod; (7)

2.2. The side thrust on the cross head guide; (2)

2.3 The turning moment on the crankshaft; (3)

2.4 The radial force in the crank. (2)

[14]

QUESTION 3

An inclined winding system consists of a motor connected to a drum through a gearbox. The gearbox has an efficiency of 85 %. The driving motor develops 20 kW at a full speed of 77 rad/s. The drum has a diameter of 1.5 m and the total reduction ratio of the gearing between the motor and a drum is 15.2. The incline gradient is 1 in 15 and the total friction is 117 N/tonne. The masses of the gearbox are equivalent to a mass of 150 kg, radius of gyration of 0.58 m at the shaft.

3.1 Calculate the total load that can be hauled up this incline at full speed. (9)

3.2 Draw the winding system arrangement and the forces on the load. (3)

3.2 If the motor can produce an extra 15 % of the torque it produced at full speed, calculate the acceleration possible (assuming previous friction and efficiencies remain the same). (8)

[20]

QUESTION 4

A delivery truck has a 4.1 m wheelbase. The center of gravity of this vehicle is 2.8 m behind the front wheel axle and 900 mm above the ground level. The coefficient of adhension between the tyre and the road surface is 0.68. Equal braking torque is applied to all four wheels.

4.1 Draw a free-body diagram showing all the forces acting on the truck. (6)

4.1 Calculate the minimum distance in which the truck can be stopped when it is travelling at 40 km/h. (19)

[25]

QUESTION 5

The total axial load (F) on a multi-collar bearing is equivalent to a mass of 15000 kg. Each collar has an internal diameter of 300 mm and an external diameter of 400 mm. The maximum pressure on each collar is 350 kPa and the shaft exerting the axial force rotates at
100 r/min.

Calculate the power absorbed as a result of friction in the bearing as well as the number of collars required if :

5.1 the pressure remains constant on each collar ; (7)
5.2 the amount of wear is constant on each collar. (6)

[13]

TOTAL = 100

ANNEXURE

Formula Sheet

Crank and Connecting rod mechanism

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

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

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

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

$$m_1 = \frac{bm}{l} \qquad m_2 = \frac{am}{l}$$

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

$$I_G = m\kappa^2 \qquad KE = \frac{1}{2}I_G\Omega^2$$

2. Friction Clutches

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

3. 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 system assuming 100% efficiency:

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

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

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