UNIVERSITY OF JOHANNESBURG

PROGRAM	:	NATIONAL DIPLOMA ENGINEERING : MECHANICAL
SUBJECT	:	**THEORY OF MACHINES III**
CODE	:	**MTH302**
DATE	:	JANUARY SSA EXAMINATION 10 JANUARY 2016
DURATION	:	(SESSION 3) 15:00 - 18:00
WEIGHT	:	40 : 60
TOTAL MARKS	:	100

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MODERATOR	:	MRS D IONESCU 2373
NUMBER OF PAGES	:	6 PAGES + 1 ANNEXURE

INSTRUCTIONS :

- ANSWER ALL QUESTIONS.
- A STUDENT IS EXPECTED TO MAKE REASONABLE ASSUMPTIONS FOR DATA NOT SUPPLIED.
- THE CANDIDATES MAY BRING INTO THE EXAM CENTRE
  - CALCULATORS OF ANY MAKE OR MODEL..
  - ANY DRAWING BOARD OR DRAFTING HEAD.
  - DRAWING INSTRUMENTS.
- 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

Figure 1 shows the configuration and velocity diagram of a link mechanism in which the link OA rotates uniformly in an anticlockwise direction at 10 rad/s. Link A'BC is pivoted at point B. Block D is constrained to move on vertical direction and is connected to the rest of the mechanism via link CD. The following data is available:
OA = 75 mm; OB = 150 mm; BC = 150 mm; CD = 300 mm and BA' = 209.84 mm.

1.1 Draw a neat sketch showing the Coriolis component of acceleration and the sliding velocity of the block A using the intermediate position given in Annexe A. (2)

1.2 Draw the complete acceleration diagram showing all salient (important) values and determine the acceleration of block D for the instant show in Figure 1. To draw your acceleration diagram, use the attached annex A where the configuration diagram and an intermediate position of the mechanism are shown for your convenience. Start the acceleration diagram at the point indicated in Annexe A. (19)

Recommended scale: 1 m/s² = 20 mm

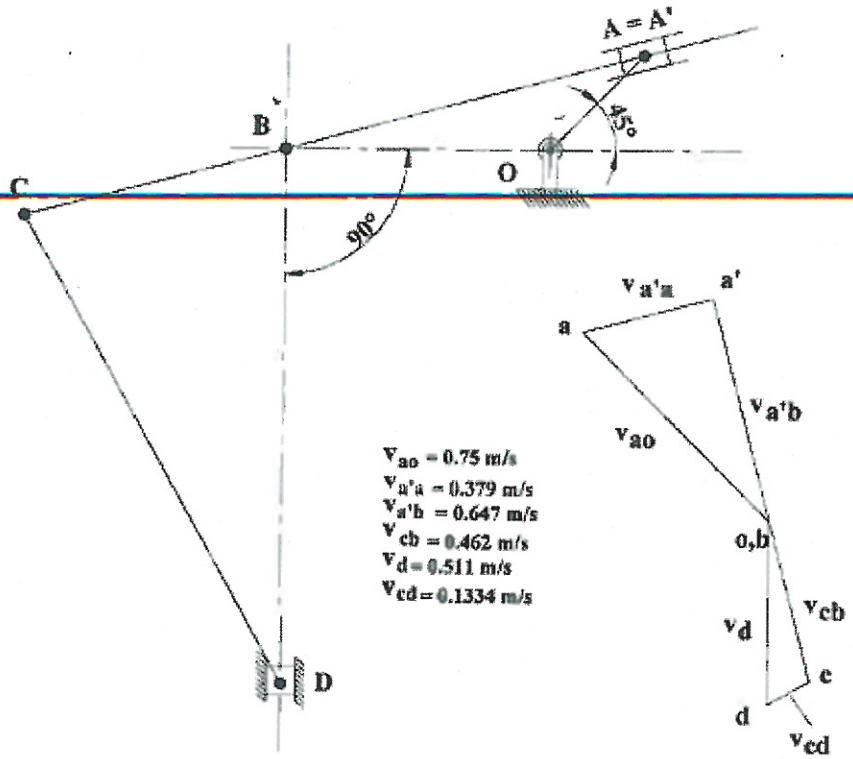

Figure 1

N.B.

- ***Draw your acceleration diagram considering the following;***
  - ***Start with the centripetal acceleration of crank OA;***
  - ***Determine the position of point A' by using the centripetal and tangential components of acceleration of point A' relative to block A and the centripetal and tangential components of acceleration of point A' relative to B;***
  - ***Determine the position of point C using proportion rule***
  - ***Determine the position of point D using centripetal and tangential components of acceleration of point D relative to C***

- ***All acceleration values must be expressed in acceleration units and written on the acceleration diagram.***
- ***No marks will be allocated for values without units or without showing the calculation used to obtain the values.***
- ***Acceleration values obtained by measurement from the diagram must be specified i.e. $f = 10\ m/s^2$ (measured).***
- ***Do not forget to insert Annexe A in your answer booklet.***

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QUESTION 2

A circular arc cam operating a flat-faced follower has the following dimensions:

- Base radius = 16 mm.
- Maximum lift = 14 mm.
- Nose radius = 3 mm.
- Total angle of action = 180°.

For the data given, determine:

2.1 The angle at which the cam transfers the follower from flank to nose. (4)

2.2 The change in acceleration of the follower if the camshaft rotates at 1260 rev/min. (7)

2.3 The force necessary to prevent the follower from losing contact with the cam at this speed at the point of maximum lift. The follower has a mass of 0,4 kg. (4)

The following formulae may be used:

$$F = mf + mg$$

$$d + r - R + x$$

Cam curved flank:

$$x = (\rho - R)(1 - \cos\theta) \qquad \rho = \frac{R^2 - r^2 + d^2 - 2Rd\cos\alpha}{2(R - r - d\cos\alpha)}$$

$$v = \omega(\rho - R)\sin\theta$$

$$f = \omega^2(\rho - R)\cos\theta \qquad \sin\psi = \frac{d\sin\alpha}{\rho - r}$$

Cam nose

$$x = (d\cos\phi + r) - R$$

$$v = -\omega d\sin\phi$$

$$f = -\omega^2 d\cos\phi$$

Figures 2.2 and 2.2 show the general geometry of curved flank cam and the displacement, velocity and acceleration diagram.

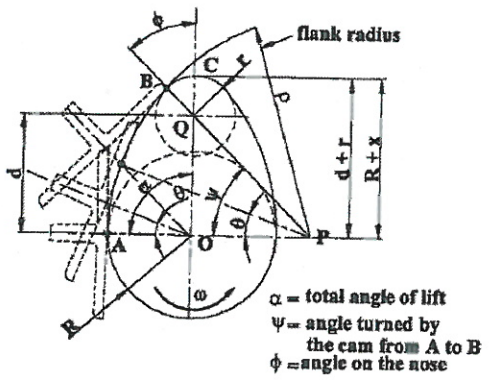

Figure 2.1

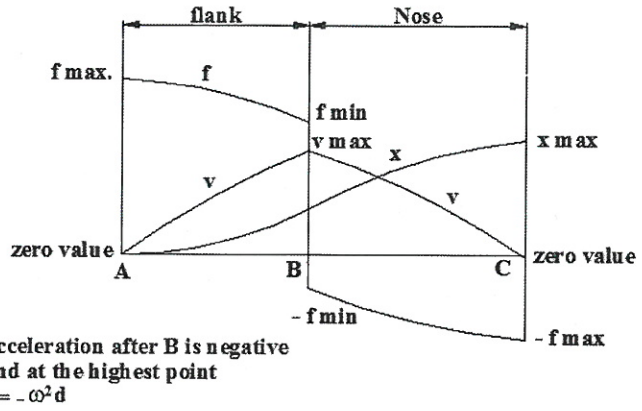

Figure 2.2

[15]

QUESTION 3

In a reciprocating engine which has four cylinders in line spaced at 140 mm apart, the reciprocating masses are 0,5 kg per cylinder, the stroke is 120 mm and the connecting rods are 450 mm long. The firing order of the engine is 1 – 4 – 2 – 3, the cranks are set at 90° to each other and the engine speed is 2000 rev/min. from the data given:

3.1 Make a neat sketch of the arrangement showing the crank positions. (2)

3.2 Determine the maximum out of balance primary and secondary forces. (15)

3.3 Determine the maximum out of balance primary and secondary couples. (13)

[30]

QUESTION 4

An engine is directly coupled to a machine, and both torques, of the engine (supplied) and machine (resisting) can be approximated by cosines function shapes, where $T_{engine} = Te = 40 + 5\ Cos\ 2\theta$ and $T_{machine} = Tr = 40 + 10\ Cos\ \theta$. Figure 2 shows the two cosines functions and their maximum and minimum values, calculate using the given torques formulae. If the mean speed is 1200 rev/min, determine:

4.1 The average power developed by the engine. (3)

4.2 The maximum fluctuation of energy. (10)

4.3 The fluctuation of speed if the total moment of inertia of the rotating parts is 2 kgm^2. (1)

4.4 The magnitude of the maximum and minimum speed and the crank angle at which it occur. (6)

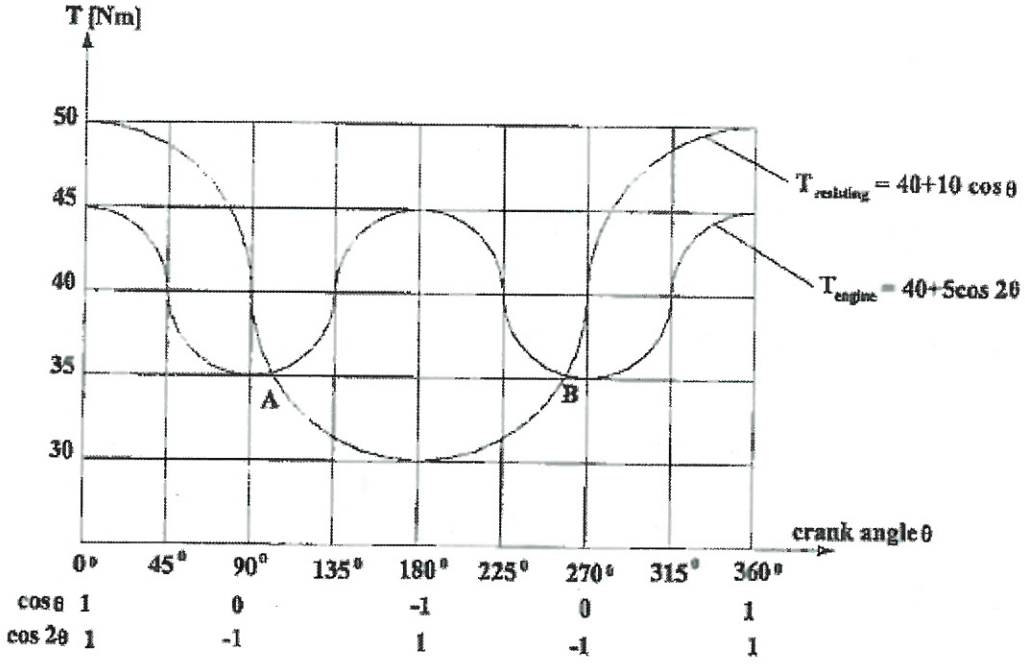

Figure 3

N.B.

- ***Calculate the crank angles corresponding to point "A and B" where Tr = Te.***
- ***Calculate "U" by intergration of $[T_e - T_r]$ from A to B.***
- ***The maximum acceleration will occur where the slopes of both curves are equal. Once the values of angle θ are calculated (quadratic equation in terms of cosθ), choose the right value considering the graphic representation from figure 4.***

The following formulae mabe used:

$$P = T_{average} \times \omega;\quad \omega = \frac{2\pi N}{60};\quad \cos 2\theta = 2\cos^2\theta - 1;\quad \int_a^b \cos\theta d\theta = [\sin b - \sin a];$$

$$\int_a^b \cos 2\theta d\theta = \left[\frac{\sin 2b}{2} - \frac{\sin 2a}{2}\right];\quad C = \frac{U}{I\times\omega^2};\quad C = \frac{\omega_1 - \omega_2}{\omega};\quad \omega = \frac{\omega_1 + \omega_2}{2}$$

[20]

QUESTION 5

The turbine rotor of a ship has a mass of 25 tones, a radius of gyration of 700 mm and rotates at 2500 rev/min in a clockwise direction as viewed from aft (aft = near or toward the back of the ship). The ship pitches through a total angle of 15^0, $7{,}5^0$ above and $7{,}5^0$ below the horizontal, the motion being simple harmonic (SHM) and having a period of 10 seconds. For the data given:

5.1 Determine the maximum gyroscopic couple on the holding-down bolts on the turbine (11)

5.2 The direction of yaw (yaw = turn unsteadily of a straight or correct course) as the bow (front part of a ship) rises. (3)

[17]

TOTAL = 100

ANNEX A

Initials & Surname:	**Student No.:**