UNIVERSITY OF JOHANNESBURG

PROGRAM	:	NATIONAL DIPLOMA *ENGINEERING : MECHANICAL*
SUBJECT	:	**THEORY OF MACHINES III**
CODE	:	**MHT302**
DATE	:	NOVEMBER EXAMINATION 21 NOVEMBER 2016
DURATION	:	(SESSION 1) 08:30 - 11:30
WEIGHT	:	40 : 60
TOTAL MARKS	:	100

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MODERATOR	:	MS D IONESCU 2373
NUMBER OF PAGES	:	5 PAGES

INSTRUCTIONS TO STUDENTS

- 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.

REQUIREMENTS

- 1 SHEET OF A4 DRAWING PAPER.

QUESTION 1

Figure 1 shows the configuration and velocity diagram of Withworth quick-return mechanism where crank AB rotates about a fixed center A. The end b operates a slider reciprocating in a slotted link DE rotating about a fixed point D. The crank AB which is 100 mm long, rotates uniformly in a clockwise direction at a speed of 100 rev/min.

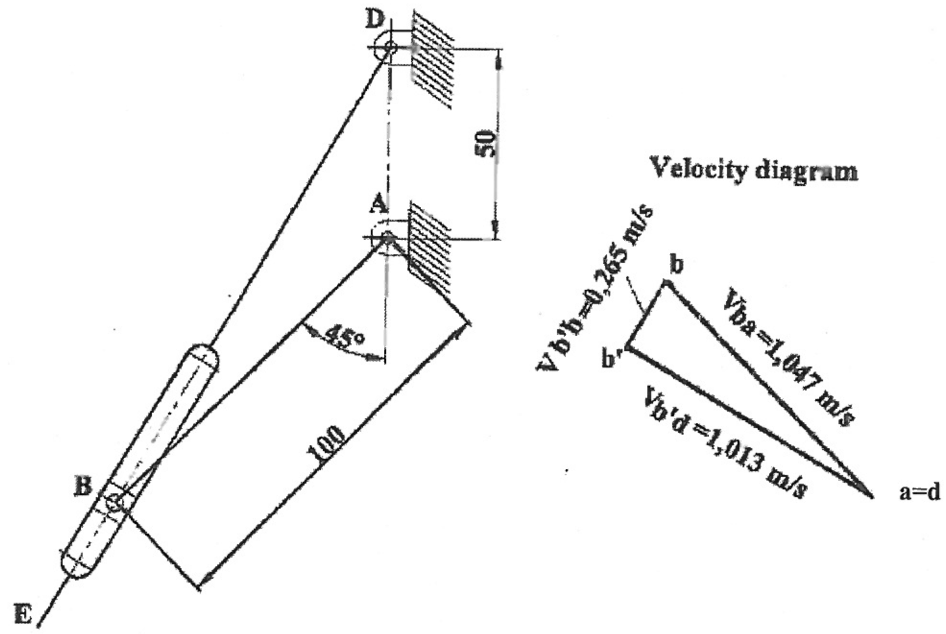

Figure 1

1.1. On the A3 size drawing paper provided, draw a neat sketch showing the direction, sense and magnitude of the Coriolis component of acceleration. (2)

1.2. Draw the acceleration diagram on the A4 size drawing paper provided. Use the given configuration diagram for the directions of the acceleration. (13)

1.3. Using the acceleration values from the diagram, determine the angular acceleration of the slotted link for the configuration shown, in which AB has turned through an angle of 45° passed its lowest position. (3)

Recommended scale: 1 m/s² = 15 mm

N.B.

- ***Do not measure any dimension from the diagram given.***
- ***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/s² (measured)***

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QUESTION 2

A cam with convex flanks, operating a flat ended follower whose lift is 18 mm, has a base circle radius of 36 mm and a nose radius of 9,6 mm. The cam is symmetrical about a line draw through the center of curvature of the nose and the center of the camshaft. If the total angle of action is 120° and the camshaft speed is 500 rev/min, determine:

2.1 The radius of the convex flanks. (4)

2.2 The maximum velocity. (4)

2.3 The acceleration / retardation magnitudes at point A, B and C. (12)

The following formulae may be used.

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.

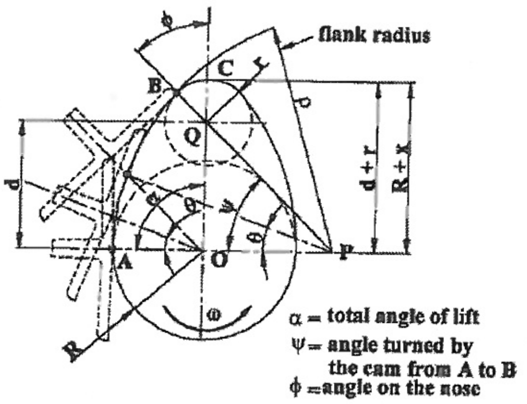

Figure 2.1

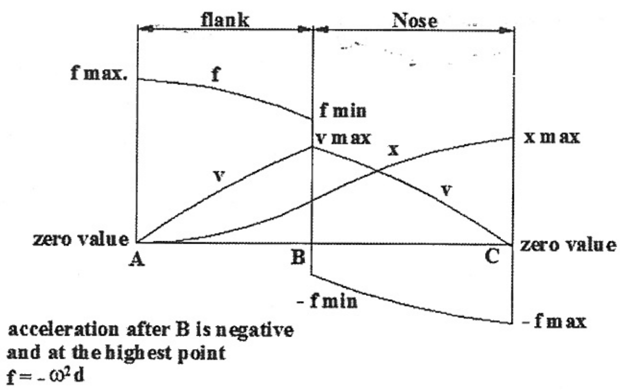

Figure 2.2

[20]

QUESTION 3

A four stroke engine has five identical cylinders with their centers lines in one plane and spaced at equal intervals of 150 mm. The reciprocating parts per cylinder have a mass of 1,5 kg, the pistons have a stroke of 100 mm and the connecting rods 175 mm long between centers. The cylinders are numbered consecutively from one end of the engine. The engine speed is 600 rev/min.

3.1 Show that the engine is in complete balance with respect to the primary and secondary forces. (15)

3.2 Determine the maximum primary and secondary couples acting on the engine. (14)

[29]

QUESTION 4

The variation of crank shaft torque of a 4 cylinder petrol engine may be approximately represented by taking a torque as zero at 0° and 180° and as 260 Nm at 20° and 45° as shown in Figure 3. The cycle is repeated every half revolution. The engine drives a machine requiring a constant torque T_r, and the engine crank shaft speed is an average of 600 rev/min. For the data given above, determine:

4.1 The mas of the flywheel of radius of gyration of 250 mm, which must be fitted in order that the total variation of speed may be limited to 1 %. (17)

4.2 The magnitude of the maximum and minimum angular velocities. (6)

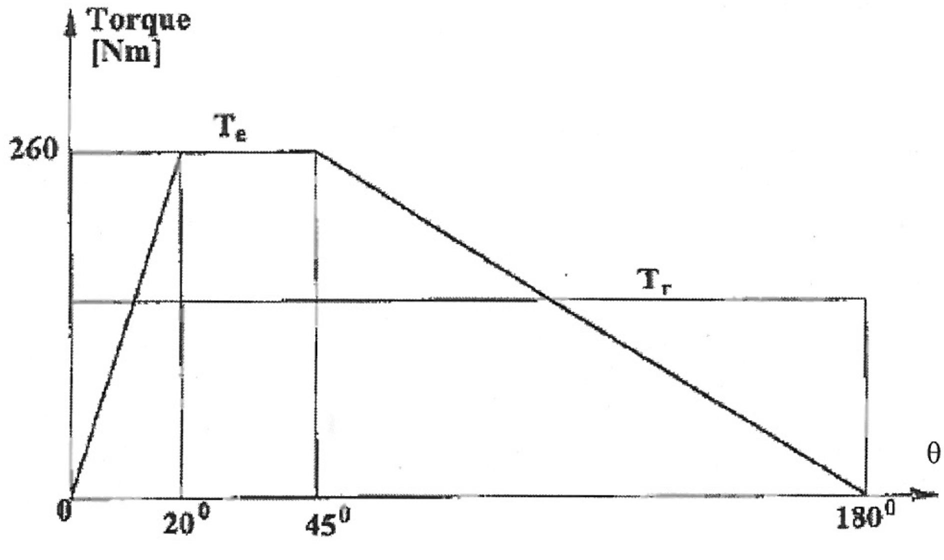

Figure 3

The following formulae may be used:

$Power = T x\omega; \; \omega = \frac{\pi N}{30} \, rad/s$

energy supplied = energy required; work done = energy = T x θ;

$$C = \frac{U}{I \times \omega^2}; \quad C = \frac{\omega_1 - \omega_2}{\omega}; \quad \omega = \frac{\omega_1 + \omega_2}{2}$$

[23]

QUESTION 5

A top of mass 0,3 kg is rotating at $\omega = 50$ rad/s and is precessed about the vertical axis at Ω rad/s. the axial and transverse moments of inertia of the top, about point "O" are 0,01 kgm^2 and 0,005 kgm^2 respectively. The angle of precision is $\theta = 30^\circ$ as shown in Figure 4 – a. Figure 4 – b is the precessed top free body diagram, where the gyroscopic couple C_1 (axial moment) and C_2 (transverse moment) are shown. Ignoring the centrifugal effects, calculate the angular velocity of precession Ω when the center of gravity is 50 mm from "o".

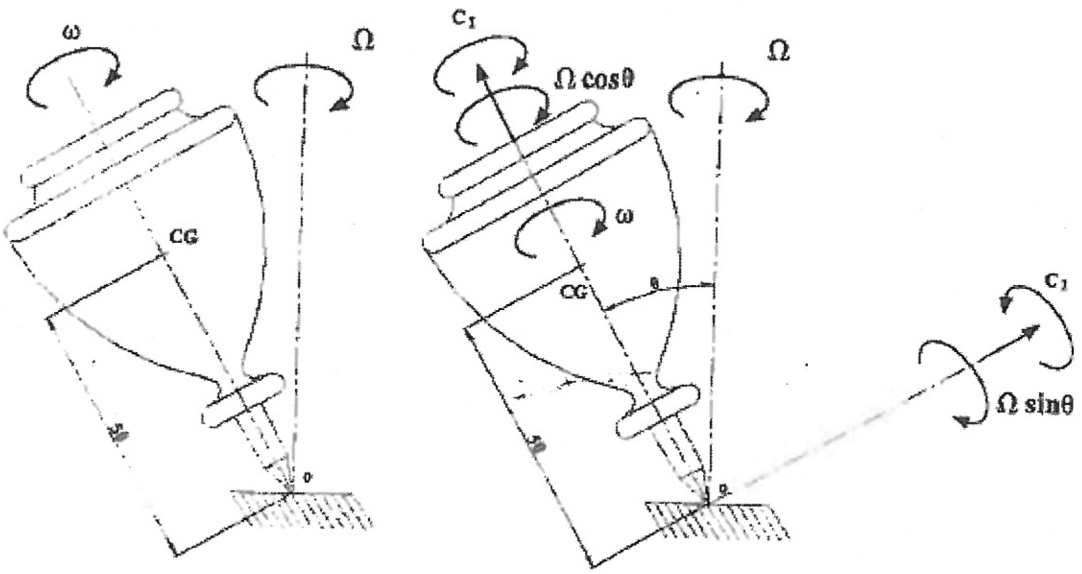

Figure 4 – a Figure 4 – b

The following formulae may be used:

Gyroscopic couple: $C = I\,\omega\,\Omega$

[10]

TOTAL = 100