UNIVERSITY OF JOHANNESBURG

PROGRAM	:	NATIONAL DIPLOMA *ENGINEERING : MECHANICAL*
SUBJECT	:	**THEORY OF MACHINES III**
CODE	:	**MHT302**
DATE	:	JANUARY SSA EXAMINATION 07 JANUARY 2020
DURATION	:	(1500 – 1800) 3HRS
WEIGHT	:	40 : 60
TOTAL MARKS	:	92

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MODERATOR	:	DR L. MTHEMBU	FILE NO:
NUMBER OF PAGES	:	7 PAGES	

INSTRUCTIONS

1. PLEASE ANSWER **ALL** QUESTIONS
2. MAKE SURE THAT YOU UNDERSTAND WHAT THE QUESTION REQUIRES BEFORE ATTEMPTING THEM.
3. ANY ADDITIONAL EXAMINATION MATERIAL IS TO BE PLACED IN THE ANSWER BOOK AND MUST INDICATE CLEARLY THE QUESTION NUMBER, AND STUDENT NUMBER.
4. DRAW PROPERLY LABELLED SKETCHES WHERE REQUIRED.
   - ANSWERS WITHOUT UNITS MAY NOT BE CONSIDERED.
   - ALL ANSWERS TO BE TO THE 2ND DECIMAL POINT.
   - ALL DIMENSIONS ON DIAGRAMS ARE IN MM UNLESS OTHERWISE SPECIFIED.
5. THE CANDIDATE MAY BRING INTO THE EXAM HALL ANY DRAWING BOARDS, DRAWING INSTRUMENTS, AND CALCULATORS.

QUESTION 1

A crank system OA rotates with uniform angular velocity of 150 rad/s in the counter-clockwise direction, while turning a straight 95 mm rod AB which is connected to another member at B. Point B is linked to the reciprocating mass at C and the member DE is connected to a fixed point E as shown in Figure 1.1. The mass of the rod CB is 30 kg, the moment of inertia about this point is 0.2 kgm^2, and its centre of gravity (g) is positioned at the bisector of the line BC. Note that the length of OA = BC, and positions O and E are the only fixed points (Ignore Coriolis Effect at position C).

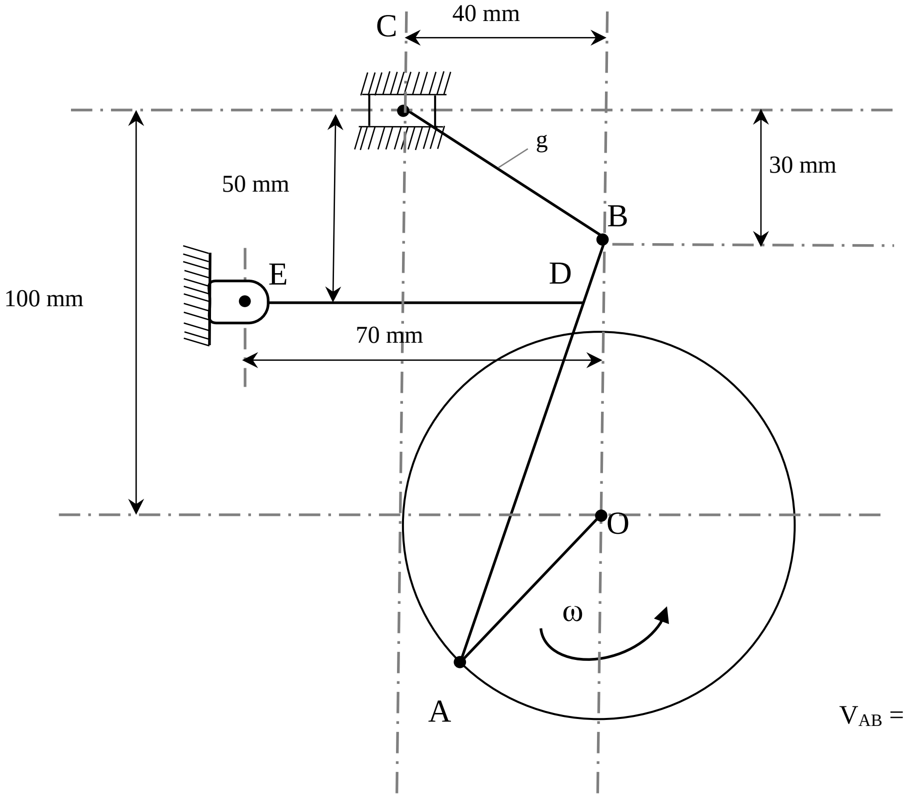


Figure 1.1

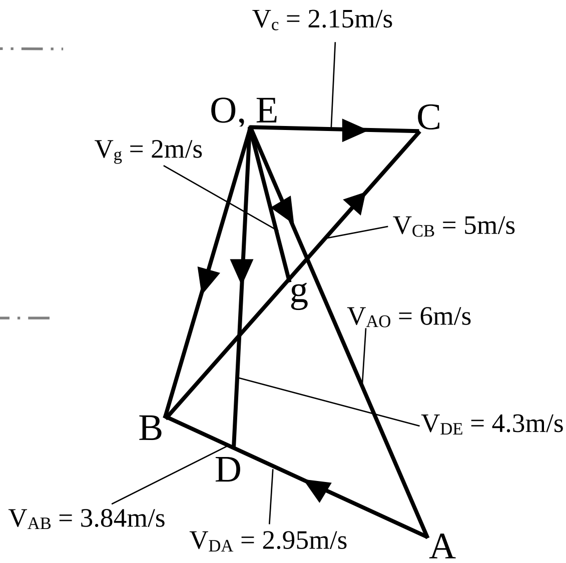


Figure 1.2

1.1 From the configuration diagram in addendum 1, determine the dimensions of DE and AD. (1)

1.2 Draw an acceleration diagram on addendum 1 sheet to scale of 1cm=100 m/s2 taking your plane from the space diagram and using the velocities provided in Figure 1.2 to obtain the centripetal component of accelerations. Label the acceleration diagram. (14)

1.3 Determine the kinetic energy of the reciprocating mass of the rod BC. (4)

[19]

QUESTION 2

MTH302 students are expected to design a machine requiring an off-the-shelf coil spring at lowest cost, which should be just sufficient to maintain constant contact without separation occurring between the tangential flank cam and circular roller surface under acceleration and deceleration. Note that the coil spring stiffness is directly proportional to cost (the higher the spring stiffness, the higher the cost). Refer to the data provided below:

Cam and follower data

Angle between flanks: 110^0

Speed: 200 rev/m

Angle between point A and B on flank: 30^0

Base circle diameter: 80 mm

Roller follower diameter: 40 mm

Nose circle diameter: 20 mm

Roller mass: 900 grams

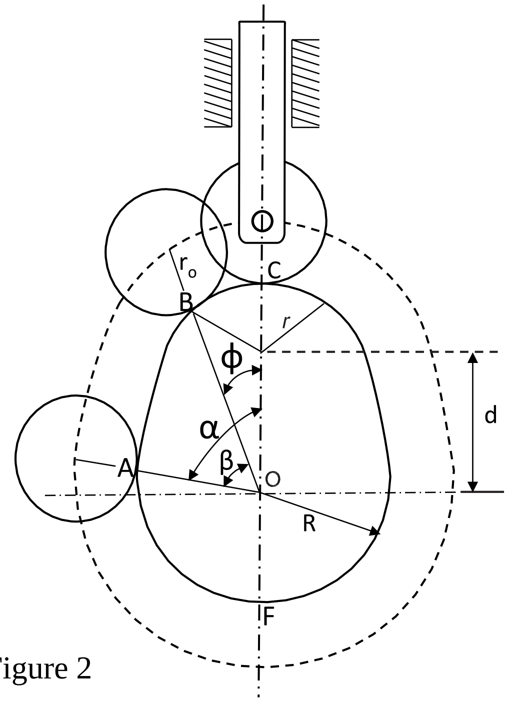


Figure 2

2.1 Determine the acceleration/retardation at point B on the flank and nose and note the values on a sketched cam acceleration diagram. (17)

2.2 Using the acceleration components obtained in (2.1) above, determine the normal radial forces acting at point B. (3)

2.3 Based on the results obtained in (2.2), referring to table 1 below, select the most suitable spring type to fulfil the conditions (adequate spring contact force at minimum cost) and justify your choice with a comment. Furthermore, using the selected spring force, determine the spring stiffness if the lift (x) = 30mm and the spring compression (y) = 50mm. (4)

Table 1

Helical spring type	Force (N)
Type 1	20
Type 2	80
Type 3	120
Type 4	160
Type 5	200

[24]

QUESTION 3

MHT302 students are expected to analyse the balance of a newly designed 6 cylinder engine (1, 2, 3, 4, 5, 6) in order to eliminate the vibrational forces. The 2 stoke engine has 100 mm cranks which are equally spaced in terms of angular displacement, and the reciprocating parts per cylinder have masses (R) of 50 kg with rotating masses (m) of 30 kg respectively. The connecting rod is four times the crank length and the cylinders are pitched at: Crank 1-2: 300 mm, Crank 2-3: 350 mm, Crank 3-4: 400 mm, Crank 4-5: 450 mm, Crank 5-6: 500 mm.

3.1 Determine the maximum unbalanced primary couple for firing order 1-6-2-5-4-3 taking the equivalent mass of each crank pin as (R+M) when the engine rotates at 300 rev/min. (15)

3.2 If the students decides to change the firing order to 1-2-3-4-5-6 without altering other design parameters; obtain the primary force/couple diagram. By visual inspection only, determine whether the primary forces/couple are balanced. Comment. (5)

[20]

QUESTION 4

A faulty gas engine directly drives a pump with equally spaced cranks. The pump requires a torque of **150 Nm** as shown by the dotted lines in **Figure 3** below. The mean engine speed (ω) is **200 rpm** and the total speed fluctuation is **28%**. The torque required diminishes sharply to zero at **270^0** as indicated by the vertical dotted lines. Label the combined torque diagram below and determine:

4.1 The maximum torque supplied. (3)

4.2 The energy fluctuation of the faulty engine at a, b, c, d, e, f, g, and h positions. Comment on your result(s). (13)

4.3 Using the maximum value of the energy fluctuation, determine the moment of inertia of the rotating parts. (5)

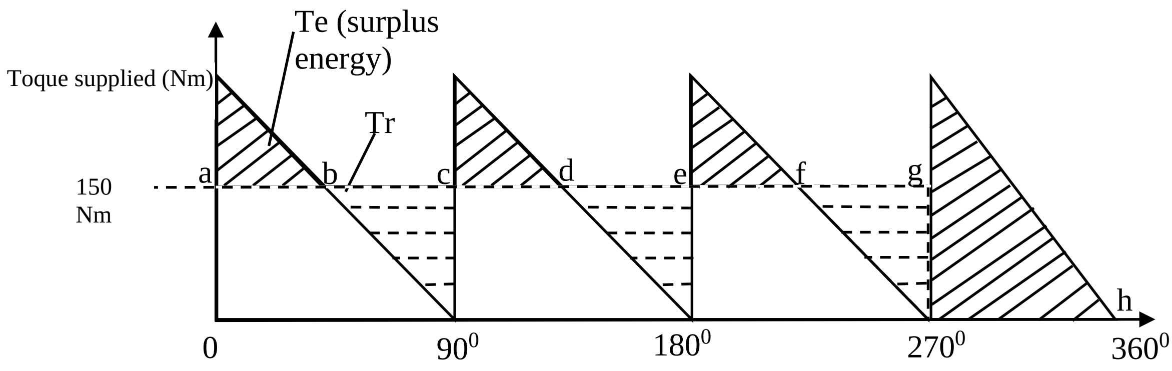


Figure 3

[21]

QUESTION 5

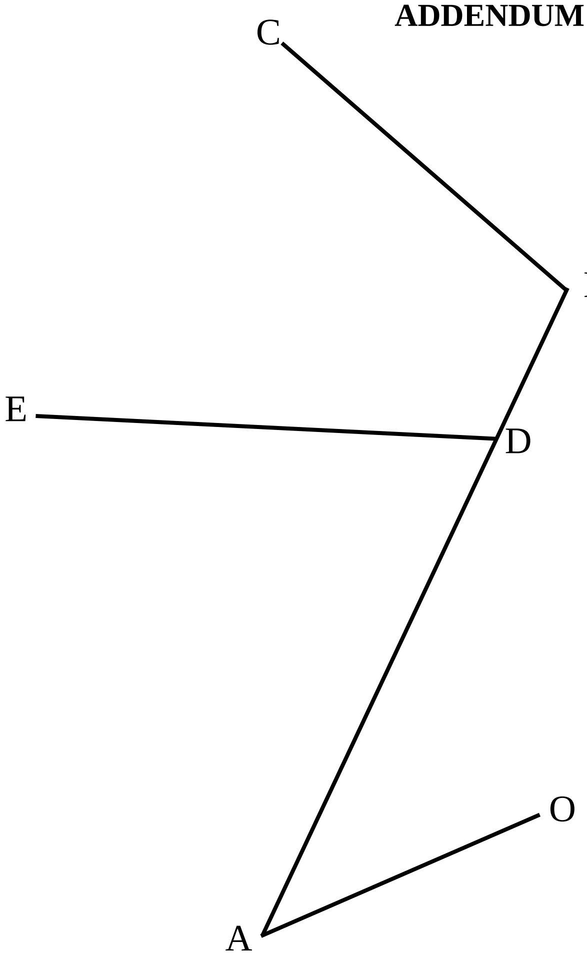
An aircraft engine rotates clockwise when viewed from the front of the aircraft. The moment of inertia of the rotating parts is 200 kgm^2. The engine rotates at 1000 rev/min.

Determine the magnitude of the gyroscopic action resulting when the airplane makes a right hand bend of radius 4000m at a speed of 1200 km/h.

[8]

TOTAL = 92

ADDENDUM 1



FORMULA SHEET

$V_{AB} = \omega \, . \, (AB)$

$ʆ_{Coriolis\,(oo')} = 2\omega \, . \, V_{oo'}$

$ʆ_{AB} = V^2_{AB} / AB$

Tan β=d sin $\alpha / R + r_o$

$n = (r + r_0) / d$

$ʆ = w^2 (R+r_0)(2 \sec^3 \Theta - \sec \Theta)$ $:::\sec \Theta = 1/\cos \Theta$

$v = \omega (R + r_0) \sec \Theta \tan \Theta$

$ʆ = - w^2 d (\cos \phi + \frac{\sin^4 \phi + n^2 \cos 2\phi}{(n^2 - \sin^2 \Phi)^{3/2}})$

$P = m ʆ$

$P' = S (x+y) + m.g$

$X = (R + r_0) \sec\Theta - (R + r_0)$

$K.E = \frac{1}{2} M . V_{og}{}^2 + \frac{1}{2} I . \omega^2$; og= C.O.G to fixed point

$P = T\omega$

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

$I = m k^2$

C or T = $I.\omega.\omega_p$

SHM: $\omega_0 = 2\pi$/Time period

$\omega_p = \varphi \, \omega_0 \cos \omega_0 t$ ::: for SHM where $\omega_0 t = 1$, then $\omega_p = \varphi \, \omega_0$

$\omega_p = \frac{V}{R}$