UNIVERSITY OF JOHANNESBURG

PROGRAM	:	BACCALAUREUS INGENERIAE *CIVIL ENGINEERING SCIENCE*
SUBJECT	:	**APPLIED MECHANICS 2A**
CODE	:	**MGACIA2 / MGA2A11**
DATE	:	SUPPLEMENTARY EXAMINATION JULY 2018
DURATION	:	(SESSION 1) 08:00 - 11:00
WEIGHT	:	50 : 50
TOTAL MARKS	:	100

ASSESSORS	:	MR P VAN TONDER MR T MAFOKOANE
MODERATOR	:	PROF S EKOLU
NUMBER OF PAGES	:	6 PAGES

INSTRUCTIONS	:	ONLY ONE POCKET CALCULATOR PER CANDIDATE MAY BE USED. NO MOBILE PHONES OR PROGRAMMABLE CALCULATORS ALLOWED
REQUIREMENTS	:	NONE

INSTRUCTIONS TO STUDENTS

ANSWER SECTION A AND B IN SEPARATE EXAMINATION BOOKS AND HAND THE BOOKS IN SEPARATELY.
ALSO HAND IN THE QUESTION PAPER.

SECTION A – STATICS

QUESTION A1 [15]

a) Derive the Euler Column Equation. (10)

$$P = \frac{\pi^2 EI}{(kL)^2}$$

b) What does an effective length of 2 mean for a column? (2)
c) What influences the effective length of a column? (3)

QUESTION A2 [10]

Draw the shear force and bending moment diagram for beam *ABC* shown in Figure 1.

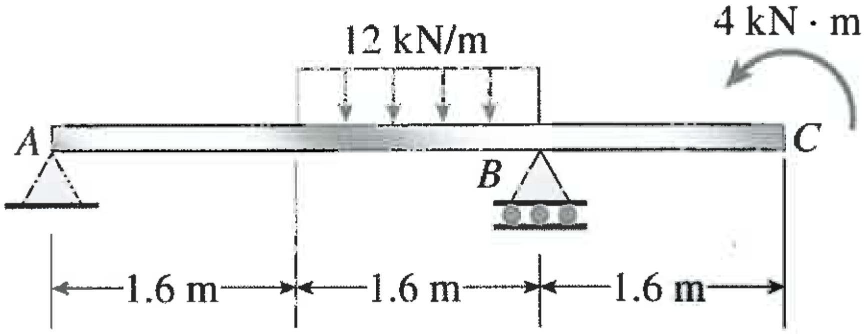

Figure 1

QUESTION A3 [8]

Determine the distance $\bar{y}$ to the centroid of the beam's cross-sectional area; then determine the moment of inertia about the x'-axis (centroid).

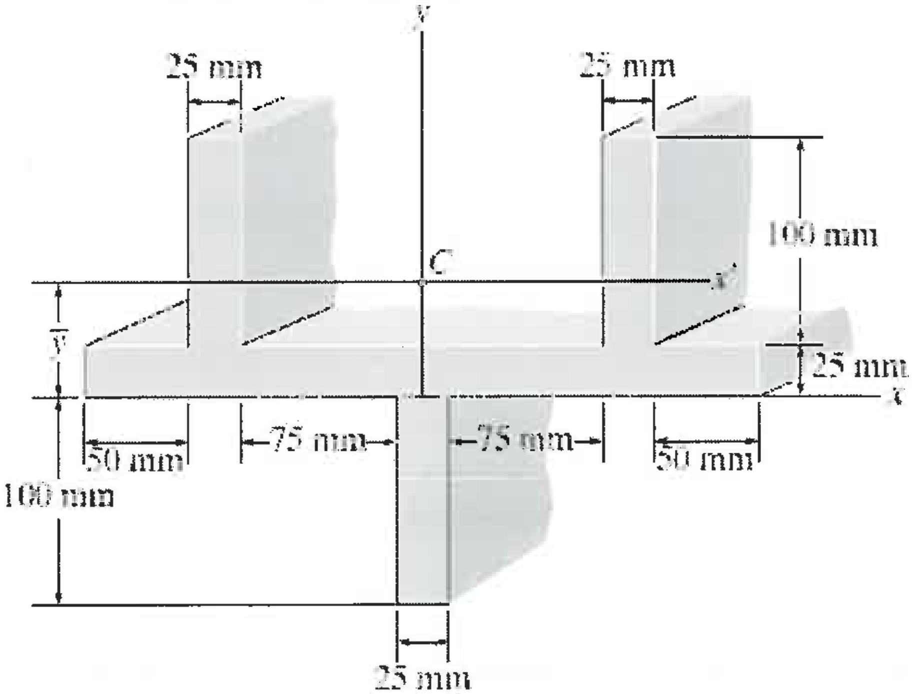

Figure 2

QUESTION A4 [7]

Two bent arms, as shown in Figure 3 support a gondola on a ski lift. Each arm is offset by a distance b = 180 mm from the line of action of the weight force W. The allowable stresses in the arms are 100 MPa in tension and 50 MPa in shear. If the loaded gondola weights 12 kN, what is the minimum diameter d of the arms?

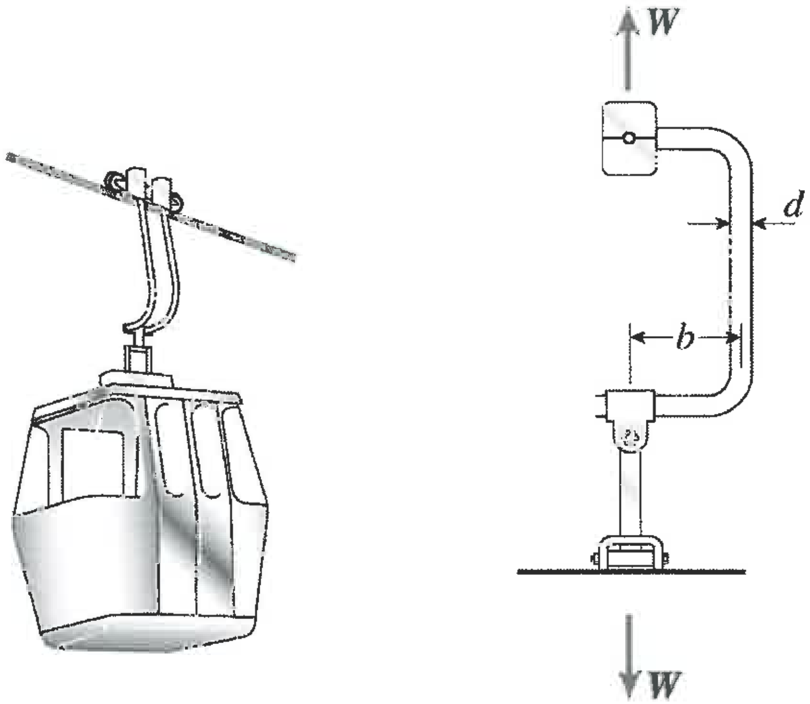

Figure 3

QUESTION A5 [10]

A simple beam AB supports a point load P acting at distances a and b from the left-hand and right-hand supports, respectively (Figure 4). Using the moment-area method, determine the maximum deflection δ_{max} of the beam.

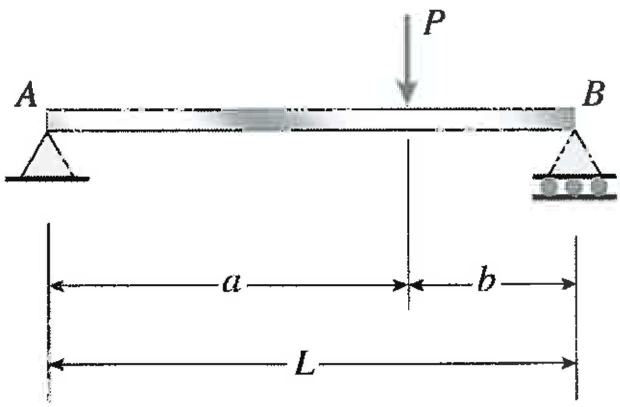

Figure 4

SECTION B – DYNAMICS

QUESTION B1 [11]

Two pulleys, one 450 mm diameter and the other 200 mm diameter, are on parallel shafts 1.95 m apart, and are connected by a crossed belt.

a) Find the length of belt required and the angle of contact between the belt and each pulley.
b) What power can the belt transmit when the larger pulley rotates at 200 rev/min, if the maximum permissible tension in the belt is 1 kN and the coefficient of friction between belt and pulley is 0.25?

QUESTION B2 [7]

The instrument shown in Figure 5 has a mass of 43 kg and is spring-mounted to the horizontal base. If the amplitude of vertical vibration of the base is 0.10 mm, calculate the range of frequencies f_n of the base vibration which must be prohibited if the amplitude of vertical vibration of the instrument is not exceed 0.15 mm. Each of the four identical springs has a stiffness of 7.2 kN/m.

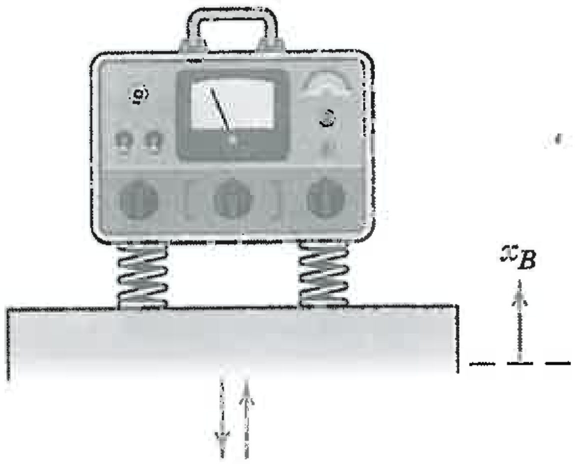

Figure 5

QUESTION B3 [15]

In a Hartnell governor, Figure 6, the length of the ball arm is 190 mm, that of the sleeve arm is 140 mm, and the mass of each ball is 2.7 kg. The distance of the pivot of each bell-crank lever from the axis of rotation is 170 mm, and the speed, when the ball arm is vertical, is 300 rev/min. The speed is to increase 0.6 percent for a lift of 12 mm of the sleeve.

a) Neglecting the dead load on the sleeve, find the necessary stiffness of the spring and the required initial compression.
b) What spring stiffness and initial compression would be required if the speed is to remain the same for the changed position of the sleeve (i.e. the governor is to be isochronous)?

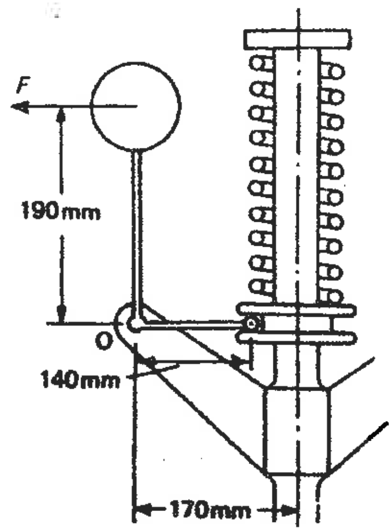

Figure 6

QUESTION B4 [7]

Figure 7 shows the side view of a door to a storage compartment. As the 40 kg uniform door is opened, the light rod slides through the collar at C and compresses the spring of stiffness k. With the door closed ($\theta = 0$), a constant force $P = 225$ N is applied to the end of the door via a cable. Neglect all friction and the mass of the pulleys at C and D. The spring is uncompressed when the door is vertical, and $b = 1.25$ m. If the door has a clockwise angular velocity of 1 rad/s as the position $\theta = 60°$ is passed, determine

a) the stiffness of the spring and
b) the angular velocity of the door as it passes the position $\theta = 45°$.

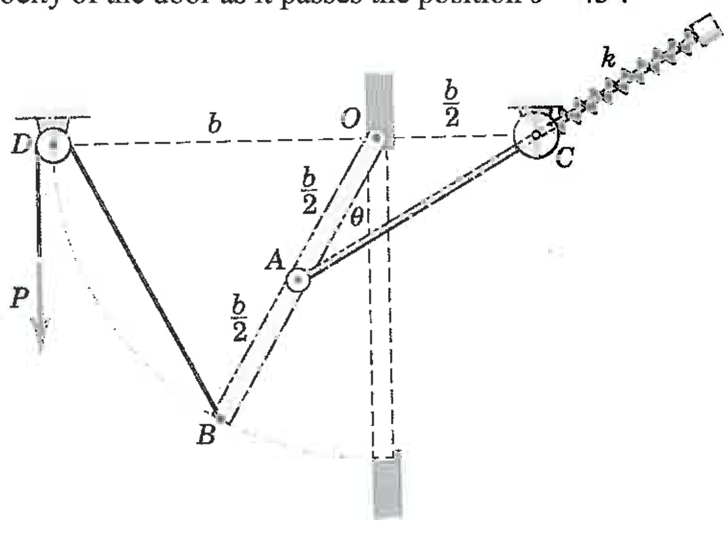

Figure 7

QUESTION B5 [10]

Proof that the acceleration of a block sliding on a rotating link are:

- $\omega^2 r$ and $r\alpha \rightarrow$ radial and tangential accelerations of the coincident link point relative to O
- f and $2v\omega \rightarrow$ radial and tangential accelerations of the block relative to the coincident link point

INFORMATION SHEET

$$X = \frac{F_0/k}{\left\{\left[1-\left(\omega/\omega_n\right)^2\right]^2 + \left[2\delta\omega/\omega_n\right]^2\right\}^{1/2}}$$

$$\phi = \tan^{-1}\left[\frac{2\delta\omega/\omega_n}{1-\left(\omega/\omega_n\right)^2}\right]$$

$$\omega_n = \sqrt{k/m}$$

$$\varsigma = c/2m\omega_n$$

$$M = \frac{1}{\left\{\left[1-\left(\omega/\omega_n\right)^2\right]^2 + \left[2\varsigma\omega/\omega_n\right]^2\right\}^{1/2}}$$

$$M = 1/[1-(\omega/\omega_n)^2]$$

$$x_p = X\sin(\omega t - \phi)$$

$$Power = (T_1 - T_c)\left(1 - \frac{1}{e^{\mu\theta / \mu\vartheta \operatorname{cosec}\beta}}\right)v$$

$$Power = (T_1 - T_2)v$$

$$\frac{T_1 - T_c}{T_2 - T_c} = e^{\mu\theta / \mu\vartheta \operatorname{cosec}\beta}$$

$$2T_0 = T_1 + T_2$$

$$x = A\cos(\omega_n t) + B\sin(\omega_n t)$$

$$T_c = mv^2$$

$$T_c = \frac{1}{3}T_1$$