(15)

Program: B. Sc. Eng. (ME)
Semester: 6th

Date: 20 February 2023 (Morning)
Time: 10:00 AM – 11:30 AM

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Mid Semester Examination
Course Code: ME 4609
Course Title: Machine Design I

Summer Semester: 2021 - 2022
Full Marks: 75
Time: 1 Hour 30 Minutes

There are **three** questions. Answer **all** of them. The symbols have their usual meanings. Marks of each question and corresponding CO and PO are written in the brackets. All sub-questions carry equal marks. This is an **OPEN BOOK Exam** (Only Textbook allowed, No notes). **Assume reasonable design data if necessary.** Programmable calculators are not allowed.

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1 (a) **Figure 1** showing several blocks ***A***, ***B***, ***C*** and a grooved block ***D*** having dimensions listed *a*, *b*, *c*, and *d* as follows: **(10)** **(CO1)** **(PO1)**

$a = 37.0 \pm 0.05$ mm, $b = 50.0 \pm 0.08$ mm
$c = 74.5 \pm 0.15$ mm, $d = 165.0 \pm 0.5$ mm

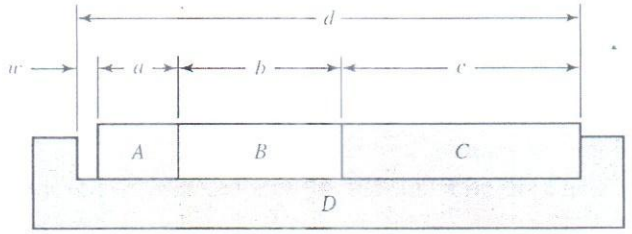

Figure 1

a) Determine the mean gap ***w*** and its tolerance.

b) Determine the mean size of ***d*** that will assure that $w \geq 0.25$ mm.

1 (b) **Figure 2** is showing a steel countershaft having two gears ***A*** and **B**. Find the deflection and slope of the shaft at point ***A***. Use superposition method assuming the bearings constitute simple support. **(15)** **(CO2)** **(PO2)**

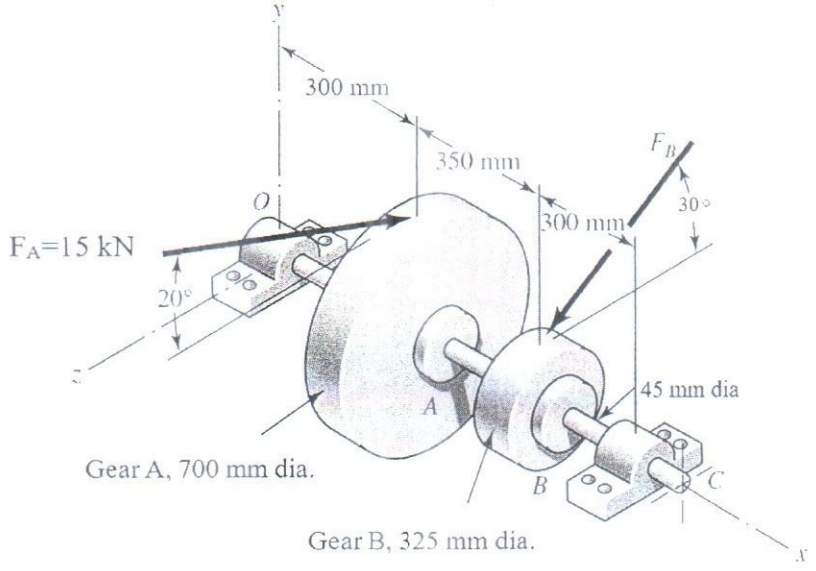

Figure 2

2. A gear reduction unit uses the countershaft shown in the **Figure 2** (Page 1). Gear A receives power from another gear with the transmitted force F_A applied as shown in figure. The power is transmitted through the shaft and delivered through gear B through a transmitted force F_B at the pressure angle shown in figure. **(25) (CO2) (PO2, PO3)**

a) Determine the force F_B, assuming the shaft is running at a constant speed.
b) Find the bearing reaction forces, assuming the bearings act as simple supports.
c) Draw shear-force and bending-moment diagrams for the shaft. If needed, make one set for the horizontal plane and another set for the vertical plane.
d) At the point of maximum bending moment, determine the bending stress and the torsional shear stress.
e) At the point of maximum bending moment, determine the principal stresses and the maximum shear stress.

3. **Figure 3** shows a linkage where, the horizontal link 4 is pinned to the ground at point B and pinned to links 2 and 3 at point A. Link 2 is fixed to the ground at point D. Assume that links 2 and 4 are in static equilibrium. The distances are R_{BA}= 1.5 m, R_{CA}= 3.5 m and R_{DA} = 3 m. Links 2 and 4 are made from a steel alloy with a compressive yield strength S_{yc}= 390 MPa and a modulus of elasticity E = 207 GPa. The link 2 has a hollow circular cross section with an outside diameter of 50 mm and a wall thickness of 5 mm. Using the theoretic value for the end-condition constant for link 2, determine: **(25) (CO2) (PO2, PO3)**

(a) The value of the slenderness ratio at the point of tangency between Euler's column formula and Johnson's parabolic formula
(b) The critical load acting on link 2 and the critical unit load on link 2
(c) If link 2 is replaced with a solid circular cross section of the same material with a diameter of 35 mm and force P= 50 kN, then determine the maximum length of link 2 for the factor of safety to guard against buckling of the link to be N= 2.5.

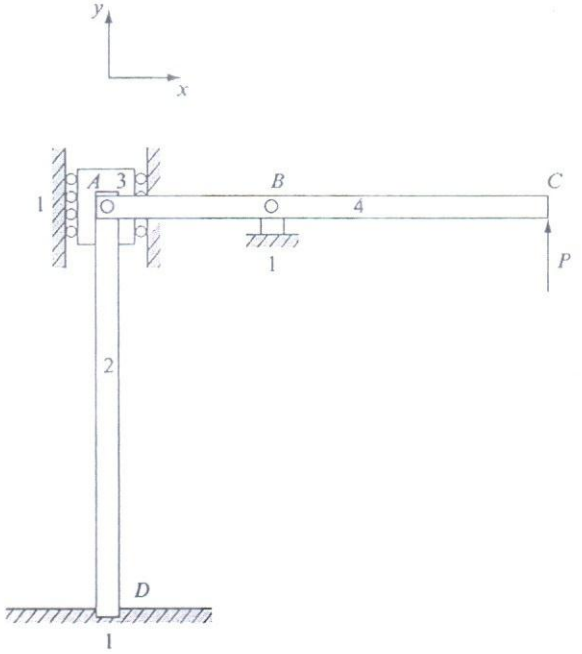

Figure 3