## DR. BABASAHEB AMBEDKAR TECHNOLOGICAL UNIVERSITY, LONERE
### Regular End Semester Examination – Summer 2022

**Course: B. Tech.**     **Branch : Mechanical Engineering**     **Semester : 6th**
**Subject Code & Name: BTMEC602, Machine Design - II**
**Max Marks: 60**          **Date:17/08/2022**          **Duration: 3.45  Hr.**

*Instructions to the Students:*
1. *All the questions are compulsory.*
2. *The level of question/expected answer as per OBE or the Course Outcome (CO) on which the question is based is mentioned in ( ) in front of the question.*
3. *Use of non-programmable scientific calculators is allowed.*
4. *Assume suitable data wherever necessary and mention it clearly.*

|  |  | (Level/CO) | Marks |
|---|---|---|---|

**Q. 1  Solve Any Two of the following.**

**A)** The following data is given for a hydrostatic thrust bearing:
thrust load = 500 kN, shaft speed = 720 rpm, shaft diameter = 500 mm, recess diameter = 300 mm, film thickness = 0.15 mm, viscosity of lubricant = 160 SUS, specific gravity = 0.86, Calculate
    (i)      supply pressure;
    (ii)    flow requirement in litres/min;
    (iii)   power loss in pumping; and
    (iv)   frictional power loss.
*(Level 3 - Apply CO1 CO2)* — **6**

**B)** A single-row deep groove ball bearing is subjected to a radial force of 8 kN and a thrust force of 3 kN. The values of X and Y factors are 0.56 and 1.5 respectively. The shaft rotates at 1200 rpm. The diameter of the shaft is 75 mm and Bearing No. 6315 (C =112 000 N) is selected for this application.
(i) Estimate the life of this bearing, with 90% reliability.
(ii) Estimate the reliability for 20 000 h life
*(Level 3 - Apply CO1 CO2)* — **6**

**C)** Derive following fundamental equation for viscous flow through rectangular slot.
$$Q = \frac{\Delta p b h^3}{12 \mu l}$$
*(Level 3 - Apply CO1 CO2)* — **6**

**Q.2  Solve Any Two of the following.**

**A)** It is required to design a pair of spur gears with 20° full-depth involute teeth consisting of a 20-teeth pinion meshing with a 50 teeth gear. The pinion shaft is connected to a 22.5 kW, 1450 rpm electric motor. The starting torque of the motor can be taken as 150% of the rated torque. The material for the pinion is plain carbon steel Fe 410 (Sut = 410 N/mm$^2$), while the gear is made of grey cast iron FG 200 (Sut =200 N/mm$^2$). The factor of safety is 1.5. Design the gears based on Lewis form factor and using velocity factor to account for the dynamic load
1. Identify the weaker element out of pinion and gear
2. Calculate the module based on beam strength
3. Calculate tangential force on gear tooth
4. Calculate beam strength and factor of safety to check if design is safe.
Refer Table for values of Lewis form factor.
*(Level 3 Apply CO4 CO5)* — **6**

**B)** A pair of parallel helical gears consists of a 20 teeth pinion meshing with a 40 teeth gear. The helix angle is 25° and the normal pressure angle is 20°. The normal module is 3 mm. Calculate
(i) the transverse module; (ii) the transverse pressure angle; (iii) the axial pitch; (iv) the pitch circle diameters of the pinion and the gear; (v) the center distance; and (vi) the addendum and dedendum circle diameters of the pinion.
*(Level 3 Apply CO4 CO5)* — **6**

**C)** Explain following terminologies of gear nomenclature with mathematical equation (wherever necessary)
1. Transmission ratio
*(Level 3 Apply CO4)* — **6**

2. Velocity ratio
3. Pressure angle
4. Circular Pitch
5. Diametral Pitch
6. Module

**Q. 3  Solve Any Two of the following.**

**A)** A pair of bevel gears, with 20° pressure angle, consists of a 20 teeth pinion meshing with a 30 teeth gear. The module is 4 mm, while the face width is 20 mm. The material for the pinion and gear is steel 50C4 ($Sut = 750$ N/mm$^2$). The gear teeth are lapped and ground (Class-3) and the surface hardness is 400 BHN. The pinion rotates at 500 rpm and receives 2.5 kW power from the electric motor. The starting torque of the motor is 150% of the rated torque. Tangential force acting on gear tooth is 1193.66 N. Determine the factor of safety **against pitting failure only**. Assume that Buckingham's equation is used to account for dynamic load.

**Data:**
1. The error 'e' for Class-3 gear teeth with 4 mm module is 0.0125 mm.
2. $C = 11400$ N/mm$^2$

**B)** A pair of worm and worm wheel is designated as 3/60/10/6. The worm is transmitting 5 kW power at 1440 rpm to the worm wheel. The coefficient of friction is 0.1 and the normal pressure angle is 20°. Determine the components of the gear tooth force acting on the worm and the worm wheel.

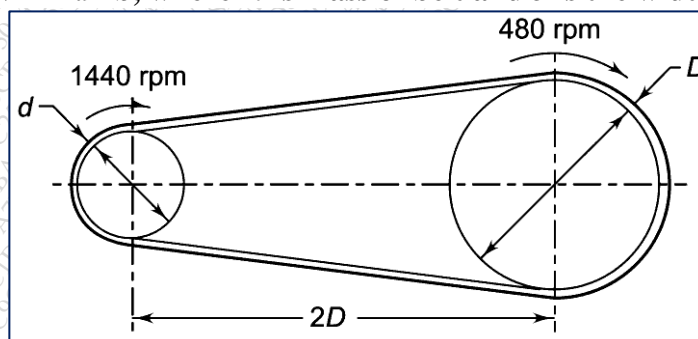**C)** Explain advantages and disadvantages of worm gears as compared to other gears.

**Q.4  Solve Any Two of the following.**

**A)** The layout of a leather belt drive transmitting 15 kW of power is shown in Fig. The centre distance between the pulleys is twice the diameter of the bigger pulley. The belt should operate at a velocity of 20 m/s approximately and the stresses in the belt should not exceed 2.25 N/mm$^2$. The density of leather is 0.95 g/cc and the coefficient of friction is 0.35. The thickness of the belt is 5 mm. Calculate:
    (i)    the diameter of pulleys;
    (ii)   the length and width of the belt; and
    (iii)  the belt tensions.
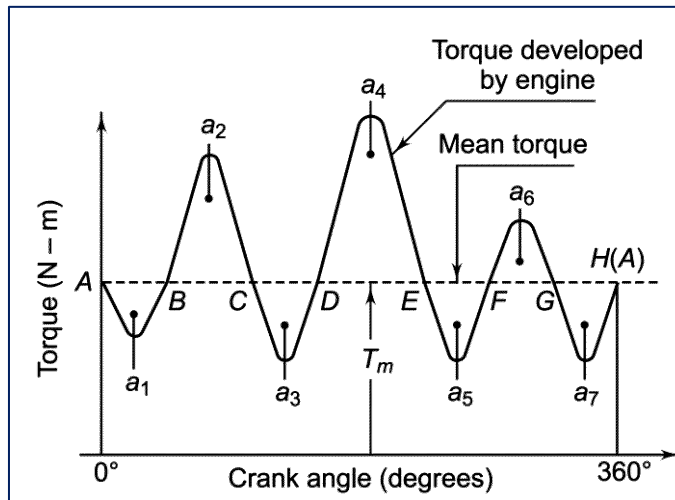Consider **$mv^2 = 1.97b$, where $m$ is mass of belt and $b$ is the width of belt**



**B)** A chain drive is used in a special purpose vehicle. The vehicle is run by a 30kW rotary engine. There is a separate mechanical drive from the engine shaft to the intermediate shaft. The driving sprocket is fixed to this intermediate shaft. The efficiency of the drive between the engine and the intermediate shafts is 90%. The driving sprocket has 17 teeth and it rotates at 300 rpm. The driven sprocket rotates at 100 rpm. Assume moderate shock conditions and select a suitable four-strand chain for this drive.

CO5

Level 3
Apply
CO4
CO5
6

Level 3
Apply
CO4
CO5
6

Level 2
Understand
CO4
CO5
6

Level 3
Apply
CO4
CO5
6

Level 3
Apply
CO4
CO5
6

Use Given data from tables for selection of various factors.

**C)**



Demonstrate the concept & mathematical equation of maximum fluctuation of energy and coefficient of fluctuation of energy by using this diagram.

Level 3
Apply
**6**

**Q. 5    Solve Any Two of the following.**

**A)**    An automotive plate clutch consists of two pairs of contacting surfaces with an asbestos friction lining. The torque transmitting capacity of the clutch is 550 N-m. The coefficient of friction is 0.25 and the permissible intensity of pressure is 0.5 N/mm$^2$. Due to space limitations, the outer diameter of the friction disk is fixed as 250 mm. Using uniform wear theory, calculate
(i) the inner diameter of the friction disk; and
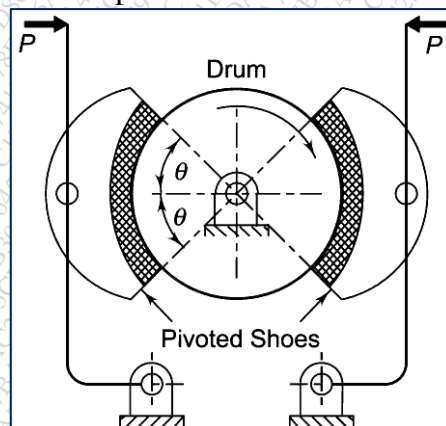(ii) the spring force required to keep the clutch in an engaged position.

Level 3
Apply
CO3
**6**

**B)**    A pivoted double-block brake, has two shoes, which subtend an angle $(2\theta)$ of 100°. The diameter of the brake drum is 500 mm and the width of the friction lining is 100 mm. The coefficient of friction is 0.2 and the maximum intensity of pressure between the lining and the brake drum is 0.5 N/mm$^2$. The pivot of each shoe is located in such a manner that the moment of the frictional force on the shoe is zero.
Calculate:
(i)      the distance of the pivot from the axis of the brake drum;
(ii)     the torque capacity of each shoe; and
(iii)    the reactions at the pivot.

Level 3
Apply
CO3
**6**



**C)**    What is the meaning of autofrettage in cylinders? Explain three methods of prestressing the cylinders.

Level 2
Understand
CO6
**6**

*** End ***

**Table – Values of Lewis Form Factor Y for 20º Full Depth Involute System**

| z | Y | z | Y | z | Y |
|---|---|---|---|---|---|
| 15 | 0.289 | 27 | 0.348 | 55 | 0.415 |
| 16 | 0.295 | 28 | 0.352 | 60 | 0.421 |
| 17 | 0.302 | 29 | 0.355 | 65 | 0.425 |
| 18 | 0.308 | 30 | 0.358 | 70 | 0.429 |
| 19 | 0.314 | 32 | 0.364 | 75 | 0.433 |
| 20 | 0.320 | 33 | 0.367 | 80 | 0.436 |
| 21 | 0.326 | 35 | 0.373 | 90 | 0.442 |
| 22 | 0.330 | 37 | 0.380 | 100 | 0.446 |
| 23 | 0.333 | 39 | 0.386 | 150 | 0.458 |
| 24 | 0.337 | 40 | 0.389 | 200 | 0.463 |
| 25 | 0.340 | 45 | 0.399 | 300 | 0.471 |
| 26 | 0.344 | 50 | 0.408 | Rack | 0.484 |

**Table – Dimensions and Static and Dynamic Load Capacities of Single Row Deep Groove Ball Bearing**

| Principal dimensions (mm) | | | Basic load ratings (N) | | Designation |
|---|---|---|---|---|---|
| d | D | B | C | $C_0$ | |
| 70 | 90 | 10 | 12100 | 9150 | 61814 |
| | 110 | 13 | 28100 | 19000 | 16014 |
| | 110 | 20 | 37700 | 24500 | 6014 |
| | 125 | 24 | 61800 | 37500 | 6214 |
| | 150 | 35 | 104000 | 63000 | 6314 |
| | 180 | 42 | 143000 | 104000 | 6414 |
| 75 | 95 | 10 | 12500 | 9800 | 61815 |
| | 115 | 13 | 28600 | 20000 | 10615 |
| | 115 | 20 | 39700 | 26000 | 6015 |
| | 130 | 25 | 66300 | 40500 | 6215 |
| | 160 | 37 | 112000 | 72000 | 6315 |
| | 190 | 45 | 153000 | 114000 | 6415 |

# Design Data for Roller Chains

**Table 14.2**  *Power rating of simple roller chain*

| Pinion speed (rpm) | Power (kW) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *06 B* | *08A* | *08 B* | *10A* | *10 B* | *12A* | *12 B* | *16A* | *16 B* |
| 50 | 0.14 | 0.28 | 0.34 | 0.53 | 0.64 | 0.94 | 1.07 | 2.06 | 2.59 |
| 100 | 0.25 | 0.53 | 0.64 | 0.98 | 1.18 | 1.74 | 2.01 | 4.03 | 4.83 |
| 200 | 0.47 | 0.98 | 1.18 | 1.83 | 2.19 | 3.40 | 3.75 | 7.34 | 8.94 |
| 300 | 0.61 | 1.34 | 1.70 | 2.68 | 3.15 | 4.56 | 5.43 | 11.63 | 13.06 |
| 500 | 1.09 | 2.24 | 2.72 | 4.34 | 5.01 | 7.69 | 8.53 | 16.99 | 20.57 |
| 700 | 1.48 | 2.95 | 3.66 | 5.91 | 6.71 | 10.73 | 11.63 | 23.26 | 27.73 |
| 1000 | 2.03 | 3.94 | 5.09 | 8.05 | 8.97 | 14.32 | 15.65 | 28.63 | 34.89 |
| 1400 | 2.73 | 5.28 | 6.81 | 11.18 | 11.67 | 14.32 | 18.15 | 18.49 | 38.47 |
| 1800 | 3.44 | 6.98 | 8.10 | 8.05 | 13.03 | 10.44 | 19.85 | — | — |
| 2000 | 3.80 | 6.26 | 8.67 | 7.16 | 13.49 | 8.50 | 20.57 | — | — |

**Table 14.3**  *Service factor ($K_s$)*

| Type of driven load | Type of input power | | |
|---|---|---|---|
| | *IC engine with hydraulic drive* | *Electric motor* | *IC engine with mechanical drive* |
| (i)  *Smooth:* agitator, fan, light conveyor | 1.0 | 1.0 | 1.2 |
| (ii)  *Moderate shock*: machine tools, crane, heavy conveyor, food mixer, grinder | 1.2 | 1.3 | 1.4 |
| (iii)  *Heavy shock:* punch press, hammer mill, reciprocating conveyor, rolling mill drive | 1.4 | 1.4 | 1.7 |

**Table 14.4**  *Multiple strand factor ($K_1$)*

| Number of strands | $K_1$ |
|---|---|
| 1 | 1.0 |
| 2 | 1.7 |
| 3 | 2.5 |
| 4 | 3.3 |
| 5 | 3.9 |
| 6 | 4.6 |

**Table 14.5**  *Tooth correction factor ($K_2$)*

| Number of teeth on the driving sprocket | $K_2$ |
|---|---|
| 15 | 0.85 |
| 16 | 0.92 |
| 17 | 1.00 |
| 18 | 1.05 |
| 19 | 1.11 |
| 20 | 1.18 |
| 21 | 1.26 |
| 22 | 1.29 |
| 23 | 1.35 |
| 24 | 1.41 |
| 25 | 1.46 |
| 30 | 1.73 |