# BACHELOR OF ENGINEERING (MECHANICAL ENGINEERING) 4TH YEAR 1ST SEMESTER EXAMINATION, 2019

## MACHINE DESIGN IV

Time: 3 hours | Full Marks: 100

(Assume data if required)

**(Answer any five)**

1. a) Derive the general expression of stresses in a thick cylinder subjected to both internal and external pressures. Show the radial and circumferential stress distributions in the cylinder for internal pressure.
   b) What is autofrettage? Define class 1, class 2 and class 3 type of pressure vessel.

14+6=20

2. a) When do you use Clavarino's and Birnie's equation for calculating cylinder wall thickness?
   b) A cylinder with external diameter 300 mm and internal diameter 200 mm is subjected to an internal pressure of 25 MPa. Compare the relative merits of a single thick walled cylinder and a composite cylinder with the inner cylinder whose internal and external diameters are 200 mm and 250 mm respectively. A tube of 250 mm internal diameter and 300 mm external diameter is shrunk on the main cylinder. The safe tensile yield stress of the material is 110 MPa and the stress set up at the junction due to shrinkage should not exceed 12 MPa.

5+15=20

3. a) Make a preliminary estimate of dead load and wind load for fabricating a plate thickness required for column of diameter 2.5 m and 60 m in height. Skirt support height is 2.5 m; 100 sieve plates are equally spaced in the column; Insulation wall thickness = 70 mm; Operating pressure = 11 bar (absolute); Joint factor = 1; Column is made of stainless steel, with design stress and design temperature of 130 N/mm2 and 2100C respectively. Take CV=1.15.
   b) Compare variation of $\left(\frac{P_i}{\sigma_{yp}}\right)$ against $\left(\frac{t}{r_i}\right)$ for different failure criteria.

15+5=20

4. a) What do you understand by stable lubrication?
   b) The following data is given for a $360^0$ hydrodynamic bearing:
   Radial load = 3.2 kN; Journal speed = 1490 rpm; Journal diameter = 50 mm; Bearing length = 50 mm; Radial clearance = 0.05 mm; Viscosity of lubricant = 25 cP; Assuming that the total heat generated in the bearing is carried by the total heat flow in the bearing, calculate i) coefficient of friction ii) power loss in friction iii) minimum oil film thickness iv) flow requirement in lit/min v) and temperature rise.

5+15=20

5. Derive the Reynold's equation. Also state all assumptions for deriving the Reynold's equation.

20

6. a) What are the selection parameters in design of journal bearing?
   b) A journal of a stationary oil engine is 80 mm in diameter and 40 mm long. The radial clearance is 0.060 mm. It supports a load of 9 kN when the shaft is rotating at 3600 rpm. The bearing is lubricated with SAE 40 oil supplied at atmospheric pressure and average

operating temperature is about $65^0$C. Using Raimondi-Boyd charts analyze the bearing assuming that it is working under steady state condition.

5+15=20

7. a) What is unimodal function? Write down the fundamental rules of region elimination methods.

   b) Write down the working principle of Golden Section method.

   c) Following data are 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: (a) Supply pressure (b) Flow requirement (c) Power loss

5+5+10=20

8. a) Assuming the relevant velocity profile of the fluid flow between two parallel plates, prove that the load carrying capacity of a hydro-static bearing is

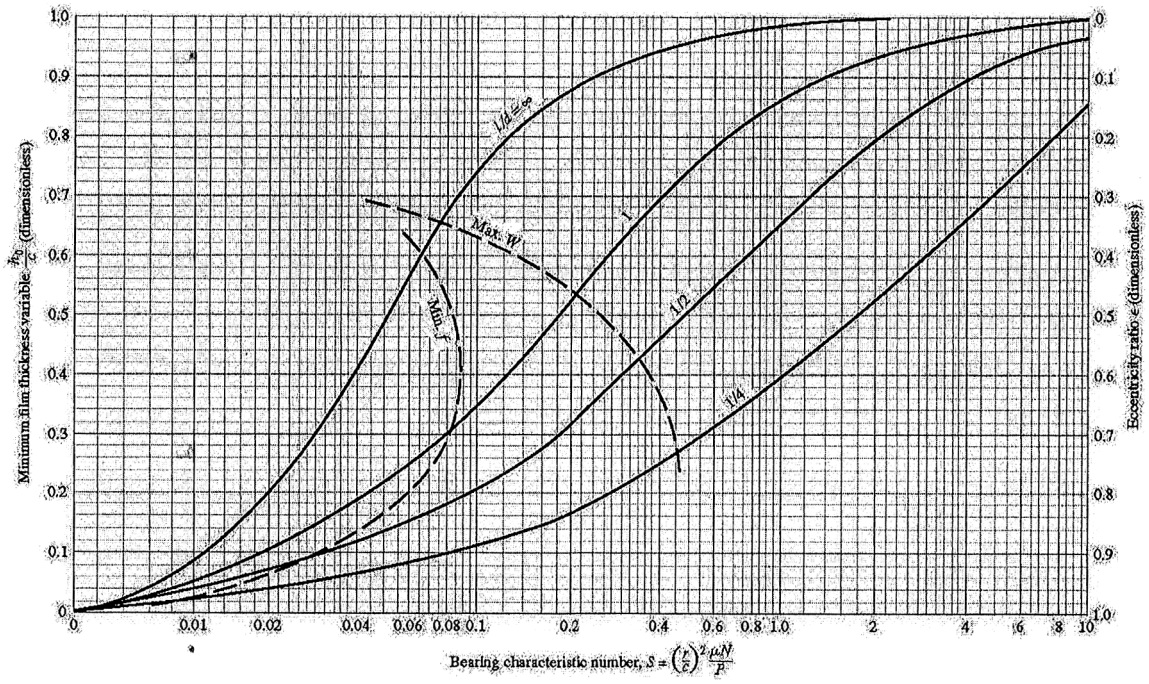
$$W = \frac{\pi P_i}{2}\left[\frac{R_o^2 - R_i^2}{\log_e\left(\frac{R_o}{R_i}\right)}\right]$$

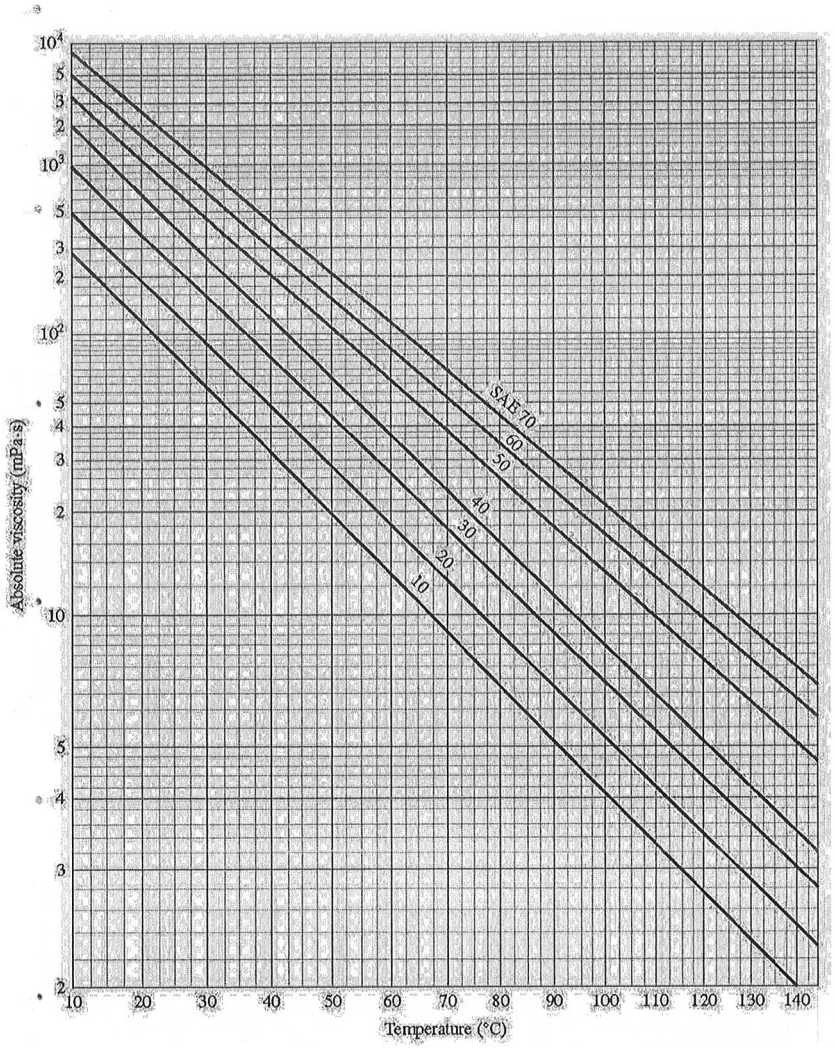
   where, $P_i$ is the inlet pressure and $R_o$ and $R_i$ are the outer are inner radii respectively.

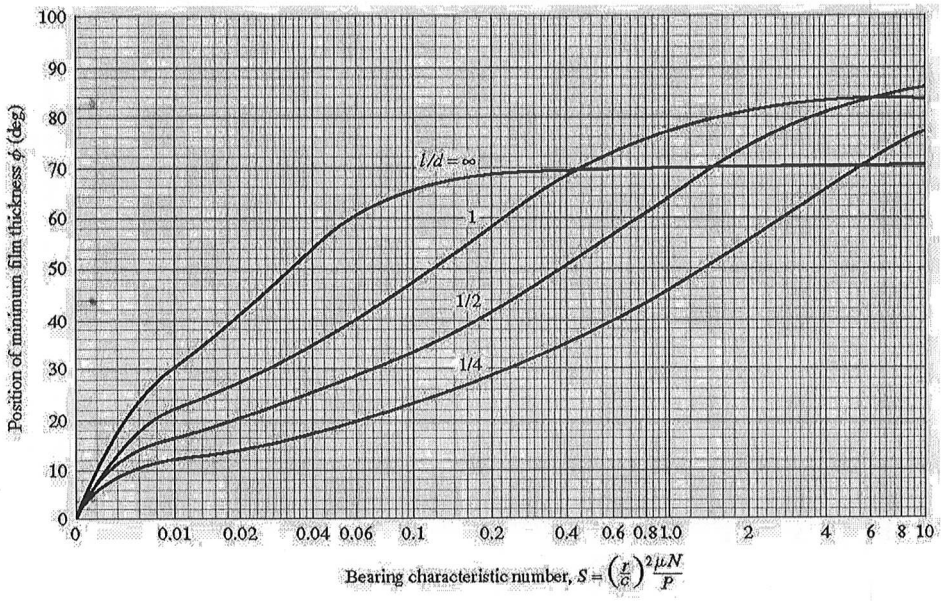
   b) Compute two steps for optimizing the given function using bisection method $f(x) = x^2 - 6x + 18$ in the range $(0, 5)$.

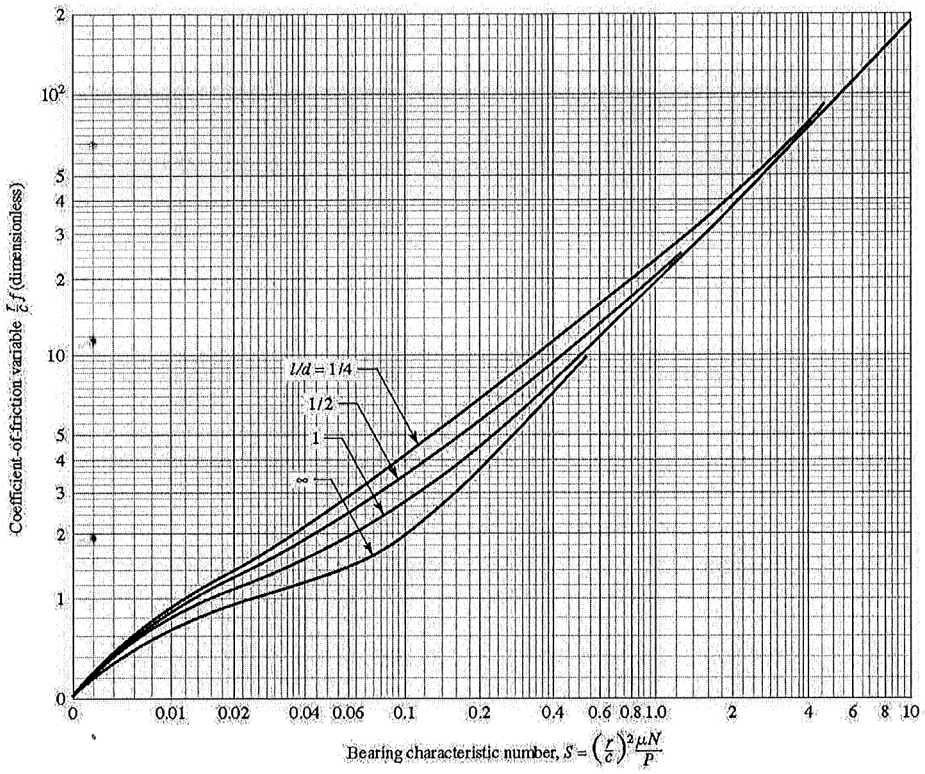
   c) What are the differences between "pulley driving belt" and "belt driving pulley"? Why are carrying run idlers more in number than return run idlers?

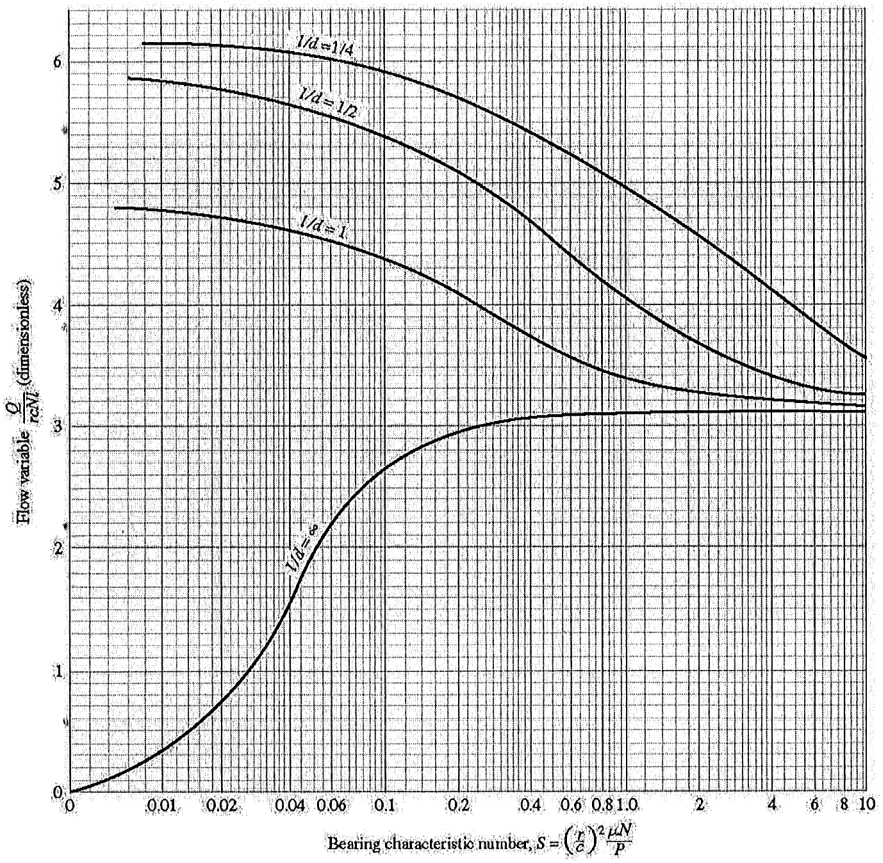
10+5+5=20

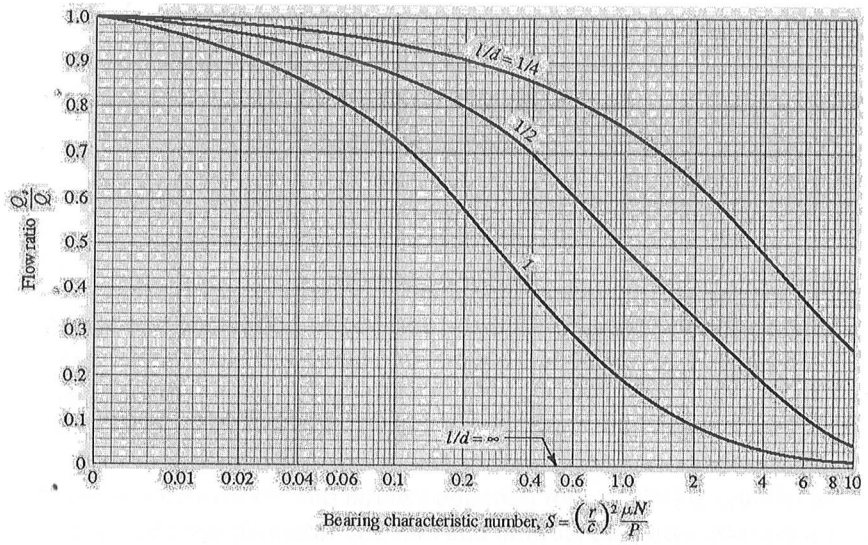


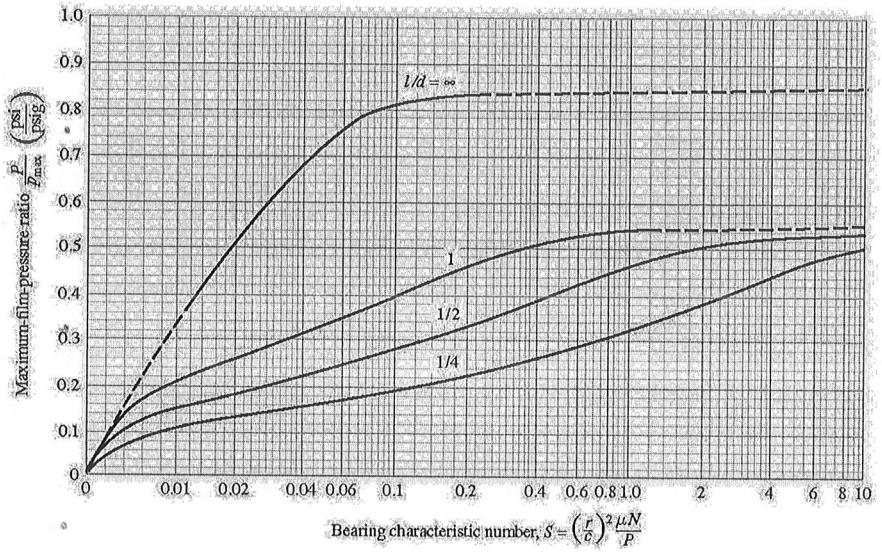

Absolute viscosity (mPa·s)
Temperature (°C)
SAE 70
60
50
40
30
20
10

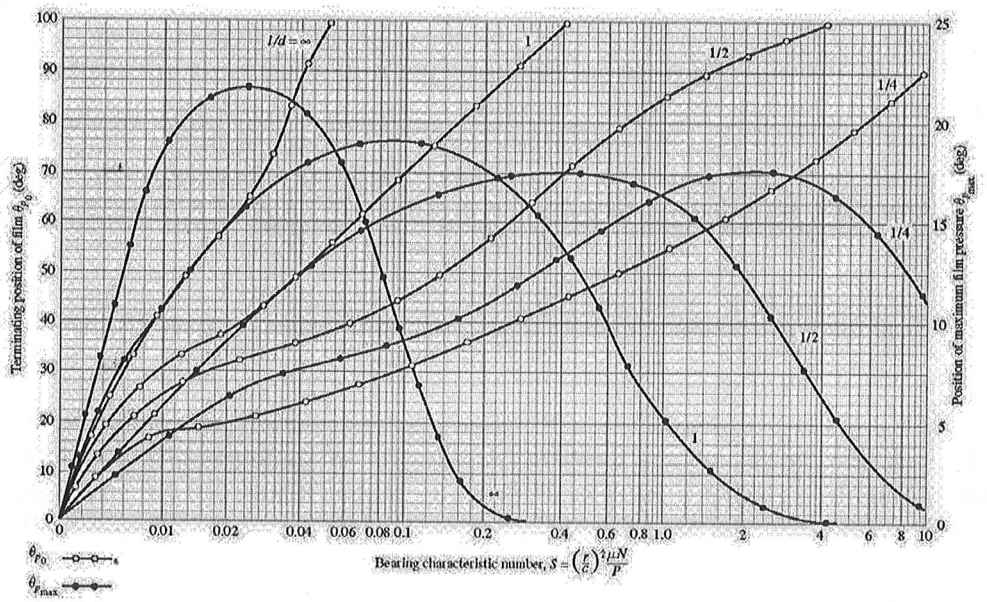

Position of minimum film thickness $\phi$ (deg)
$l/d = \infty$
1
1/2
1/4
Bearing characteristic number, $S = \left(\frac{r}{c}\right)^2 \frac{\mu N}{P}$


Coefficient-of-friction variable $\frac{r}{c}f$ (dimensionless)
2
$10^2$
5
4
3
2
10
5
4
3
2
1
0
l/d = 1/4
1/2
1
∞
0
0.01
0.02
0.04
0.06
0.1
0.2
0.4
0.6
0.8
1.0
2
4
6
8
10
Bearing characteristic number, $S = \left(\frac{r}{c}\right)^2 \frac{\mu N}{P}$


Flow variable $\frac{Q}{rcNl}$ (dimensionless)
6
5
4
3
2
1
0
l/d = 1/4
l/d = 1/2
l/d = 1
l/d = ∞
0
0.01
0.02
0.04
0.06
0.1
0.2
0.4
0.6
0.8
1.0
2
4
6
8
10
Bearing characteristic number, $S = \left(\frac{r}{c}\right)^2 \frac{\mu N}{P}$


Flow ratio $\frac{Q_s}{Q}$
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
l/d = 1/4
1/2
1
l/d = ∞
0 0.01 0.02 0.04 0.06 0.1 0.2 0.4 0.6 1.0 2 4 6 8 10
Bearing characteristic number, $S = \left(\frac{r}{c}\right)^2 \frac{\mu N}{P}$


Maximum-film-pressure ratio $\frac{p}{p_{max}}$ $\left(\frac{\text{psi}}{\text{psig}}\right)$
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
l/d = ∞
1
1/2
1/4
0 0.01 0.02 0.04 0.06 0.1 0.2 0.4 0.6 0.8 1.0 2 4 6 8 10
Bearing characteristic number, $S = \left(\frac{r}{c}\right)^2 \frac{\mu N}{P}$


Terminating position of film $\theta_{F_0}$ (deg)
Position of maximum film pressure $\theta_{P_{max}}$ (deg)
100
90
80
70
60
50
40
30
20
10
0
25
20
15
10
5
0
l/d = ∞
1
1/2
1/4
0 0.01 0.02 0.04 0.06 0.08 0.1 0.2 0.4 0.6 0.8 1.0 2 4 6 8 10
Bearing characteristic number, $S = \left(\frac{r}{c}\right)^2 \frac{\mu N}{P}$
$\theta_{F_0}$
$\theta_{P_{max}}$