BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE PILANI, DUBAI CAMPUS

II SEMESTER 2012-2013

Comprehensive Examination (Open Book)

Year : II Yr MECHANICAL	Section: 1 and 2	Date : 04.06.2013
Course No. : ME F241	Course Title : Machine Design & Drawing	
Duration : 3 hours	Marks: 80	Weightage : 40 %

Instructions: (i) *Answer all questions.*

(ii) *Marks are shown in the brackets against each question.*

(iii) Text book and hand-written class notes are only allowed.

(iv) Answer Part A & Part B on separate answer books.

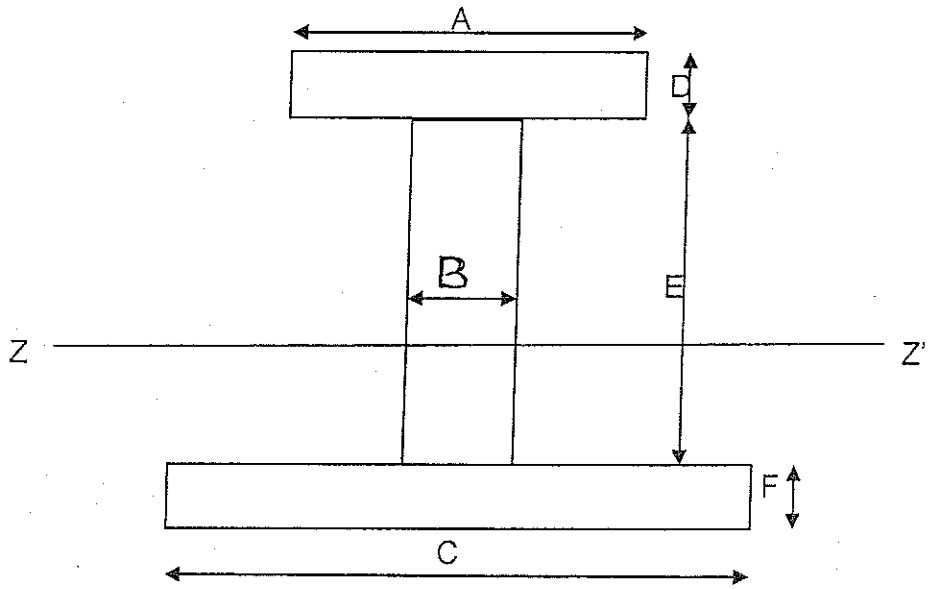
(v) Assume logically the missing data, if any.

(vi) Draw freehand sketches for all questions.

PART A

Question 1

A beam having an I section with the dimensions shown in the figure below is subjected to a bending moment of 1280N-m about the negative z-axis, which causes tension and compression on the top and bottom surfaces respectively. Locate the neutral axis and find the maximum tensile and compressive bending stresses. **[12M]**

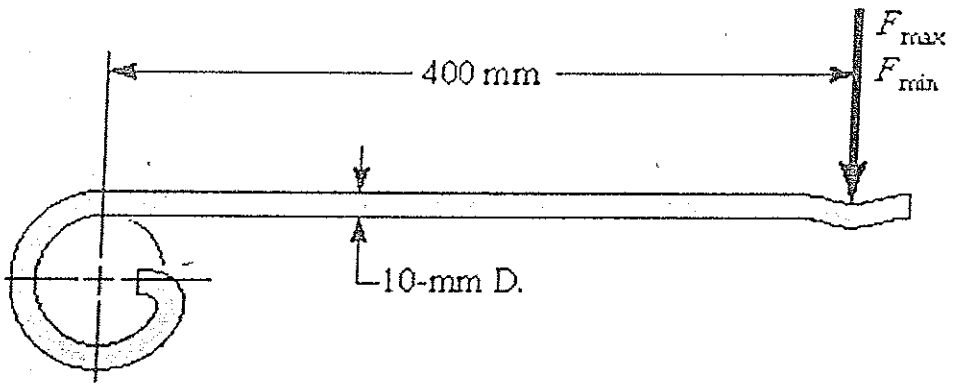


A = 50 mm, B = 20 mm, C = 72 mm, D=12 mm, E=70 mm and F=12 mm

Question 2

The figure shows a formed round-wire cantilever spring subjected to a varying force. The ultimate tensile strength of spring is 1200MPa. It is apparent from the mounting details that there is no stress concentration. A visual inspection of the springs indicates that the surface finish corresponds closely to a hot-rolled finish. Taking F_{max}= 150N & F_{min} = 50N

What number of applications is likely to cause failure? Solve using Gerber Criterion for finding the factor of safety. . [12M]



Question 3

A mild steel shaft transmits 20 kW at 200 rpm. It carries a central load of 900 N and simply supported between a bearings 3.5 meters apart. Determine the size of the shaft, if the allowable shear stress is 42 MPa and the maximum tensile or compressive stress is not to exceed 56 Mpa. [8M]

Question 4

Find the power required to drive a 50-mm power screw having double square threads with a pitch of 5 mm. The nut is to move at a velocity of 58mm/s and move a load of 9.6 kN. The frictional coefficients are 0.12 for the threads and 0.15 for the collar. The frictional diameter of the collar is 65 mm. [8M]

PART B

Question 5

A helical compression spring is made of no.14 hard drawn wire. The outside diameter of the spring is 12 mm. The ends are squared and there are 14.5 total turns.

a) Estimate the torsional yield strength of the wire.

b) Estimate the scale of the spring.

c) Estimate the deflection that would be caused by the load.

d) Is buckling a possibility? justify. **[8M]**

Question 6

A ball bearing designed for a life of 4 calendar years at a speed of 300 rpm.The radial load is

2 kN and an application factor of 1.3 is appropriated. The reliability goal is 0.85. Find the multiple of rating life required X_D and the catalog rating C_{10} with which to enter a bearing table. Choose a 02-series deep-groove ball bearing, and estimate the reliability in use. **[8M]**

Question 7

A spur gear drive is required to transmit a maximum power of 25 kW. The velocity ratio is 1:3 and speed of pinion is 250 rpm. The center distance between the shafts is 500 mm. The allowable static stresses for the bronze pinion and cast iron gear are 84 MPa and 105 MPa respectively. The face width is 10 times the module. Find the module, face width and number of teeth on each gear. The teeth should be 200 full depth involute system. This gear drive is to be designed for steady load working for 3 hrs in a day. **[12M]**

Question 8

In a horizontal open belt drive for a centrifugal blower, the blower is belt driven at 600 rpm by a 15 kW, 1750 rpm electric motor. The centre distance is twice the diameter of the larger pulley. The density of the belt material = 1500 Kg/m^3; maximum allowable stress=4 Mpa; μ_1=0.5 (motor pulley); μ_2=0.4 (blower pulley); velocity of the belt = 20 m/s. Determine the following

a) Length of the belt
b) Cross-sectional area of the belt
c) Centrifugal Tension & Maximum tension in the belt **[12M]**

BITS PILANI, DUBAI CAMPUS

II Semester 2012-2013

COMPREHENSIVE EXAM

MEF241 Machine Design & Drawing

Date: 04-06-13 — ANSWERS' SCHEME — Marks: 80

Time: 3 hrs — PART A — Weightage: 40%

Q1

Free hand Sketch	3 Marks
Location of Neutral axis	5 Marks
Moment of Inertia	4 Marks
STRESSES	2 Marks
TOTAL	12 Marks

Q2

Free hand sketch	1 Mark
Factors	3 Marks
STRESSES	2 Marks
Theories of failure Modified Goodman's Eqn	2 Marks
Problem by using Gerber's Eqn.	4 Marks
TOTAL	12 Marks

(Q3) Free hand sketch - - - 1 Marks
Finding Torque and bending moment - - 2 Mks.
" Bending & Torsion - - 2 Mks
" " - - 2 Mks
" choose shaft - - 1 Mks
TOTAL 8 Mks

(Q4) Free hand sketch - - 1 Mark
Finding Torque - - - 4 Mks
Finding Speed - - 1 Mks
Finding Power - 2 Mks
TOTAL 8 Mks

PART B

(Q5) Free hand sketch - - 1 Mark
Finding Torsional yield stress - Stg - 2 Mks
Finding scale Kb - - - 1 Mark
" deflection K - - 3 Mks
" checking for buckling - - 1 Mark
TOTAL 8 Mks

(3)

(Q6)

Ball bearing - - - - - - 1 Mark

Finding F_D (Desired Radial load) - - - 1 Mark

Finding X_D (Desired Speed) - - - 2 Marks

Finding C_{10} (Catalog Rating) - - - 1 Marks

Finding (S) - - - 1 Marks

Finding R (Reliability) - - - 2 Marks

TOTAL 8 Marks

(Q7)

Free body Sketch - - - 1 Marks

SF - - - 2 Marks

Deflection - - - 2 Marks

Calculation of 'W', Radial Modulus, Pole width & Air bubble - - - 5 Marks

TOTAL 12 Marks

(Q8)

Free body Sketch - - - 1 Mark

Calculation of chains of milling & CD - - - 2 Marks

Length of the belt - - - 1 Mark

" " Angle Θ = 1 Mark

~~" " " = 1 Marks~~

" " Tension Ratio - - - 2 Marks

~~Search for Tension - - - 2 Marks~~

~~Calculation of Torque~~ - - - 2M

~~Calculation of~~ Tensions - - - 1 Marks

~~Calculation of T1, T2 - - - 2 Marks~~

~~Calculation Torque - - - 2 Marks~~

~~Dec Arc/S~~ (2) TOTAL 12 Marks

Motor Power

FBS - 1M

r1, r2, x - 3M

L - 1M

Θ - 1M

T1, T2 - 2M

Tc, Tm - 2M

~~C/S - 2M~~ 1M

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE PILANI, DUBAI CAMPUS

II SEMESTER 2012-2013

TEST No.2 (Open Book)

Year : II-MECHANICAL	Section: 1 and 2	Date : 29.04.2013
Course No. : ME F241	Course Title : Machine Design & Drawing	
Duration : 50 minutes	Marks: 40	Weightage : 20 %

Notes: (i) *Answer all the questions*

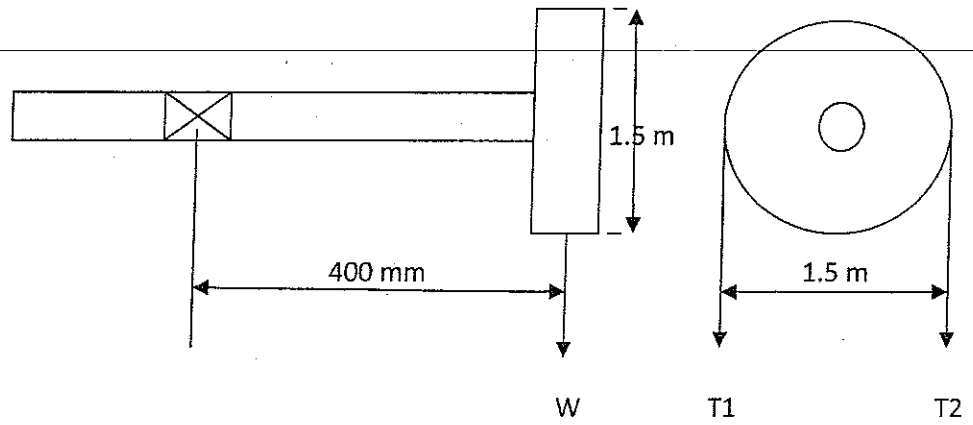
(ii) *All questions carry 10 marks each*

(iii) Text book and hand-written class notes are only allowed

(IV) Assume logically missing data, if any.

Question 1

A line shaft is driven by means of a motor placed vertically below it. The pulley on the line shaft is 1.5 meter in diameter and has belt tension 5.4 KN and 1.8 KN on the tight side and slack side of the belt respectively. Both these tensions may be assumed to be vertical. If the pulley be hangover from the shaft, the distance of the centre line of the pulley from the centre line of the bearing being 400mm, neglecting the weight of the pulley, find the diameter of the shaft. Assuming maximum allowable shear stress of 42MPa and bending stress of 86MPa.



Question 2

The cylinder head of a steam engine is subjected to a steam pressure of 1.2 MPa. It is held by means of 12 bolts. The effective diameter of Cylinder is 300mm., the stress in the bolts is not to exceed 100MPa, Assuming thickness of cylinder as 10mm.

1. Find the size of the studs required to fix the cylinder cover
2. Justify the result for a leak proof joint

Question 3

A sluice valve, used in a water-pipeline, consists of a gate raised by the hand wheel. The spindle has single-start square threads. The nominal diameter is 36mm and the pitch is 6mm. The diameter of the friction collar is 40mm. The coefficients of friction at the threads and the collar are 0.15 and 0.20 respectively. The weight of the gate is 7.5kN

Calculate:

1. the torque required to raise the gate
2. the torque required to lower the gate; and
3. the overall efficiency of the mechanism

Question 4

A rectangular bar is cut from an AISI 1018 cold-drawn steel flat. The bar is 60 mm wide by 10 mm thick and has a 12-mm hole drilled through the center as depicted in Table A-13-1. The bar is concentrically loaded in push-pull fatigue by axial forced Fa, uniformly distributed across the width. Using a design factor of nf =1.8, estimate the largest force Fa that can be applied ignoring column action. Taking Sut=440 MPa

DATA SHEET FOR FATIGUE LOADING

$$\frac{S_e}{n_f} = K_f \frac{F_a}{A}$$

$$S_e = k_a k_b k_c k_d k_e k_f S'_e$$

$$S'e = \begin{cases} 0.5Sut & \text{for } Sut \le 1400 \text{ MPa} \\ 700 \text{ MPa} & \text{for } Sut > 1400 \text{ MPa} \end{cases}$$

Surface Factor k_a

$$k_a = a S_{ut}^b$$

Surface Finish	Factor a S_{ut}, kpsi	Factor a S_{ut}, MPa	Exponent b
Ground	1.34	1.58	−0.085
Machined or cold-drawn	2.70	4.51	−0.265
Hot-rolled	14.4	57.7	−0.718
As-forged	39.9	272.	−0.995

Size Factor k_b

The size factor has been evaluated using 133 sets of data points. The results for bending and torsion may be expressed as

$$k_b = \begin{cases} (d/0.3)^{-0.107} = 0.879d^{-0.107} & 0.11 \le d \le 2 \text{ in} \\ 0.91d^{-0.157} & 2 < d \le 10 \text{ in} \\ (d/7.62)^{-0.107} = 1.24d^{-0.107} & 2.79 \le d \le 51 \text{ mm} \\ 1.51d^{-0.157} & 51 < d \le 254 \text{ mm} \end{cases}$$

For axial loading there is no size effect, so

$$k_b = 1$$

Loading Factor k_c

When fatigue tests are carried out with rotating bending, axial (push-pull), and torsional loading, the endurance limits differ with S_{ut}.

$$k_c = \begin{cases} 1 & \text{bending} \\ 0.85 & \text{axial} \\ 0.59 & \text{torsion} \end{cases}$$

DATA SHEET FOR FATIGUE LOADING

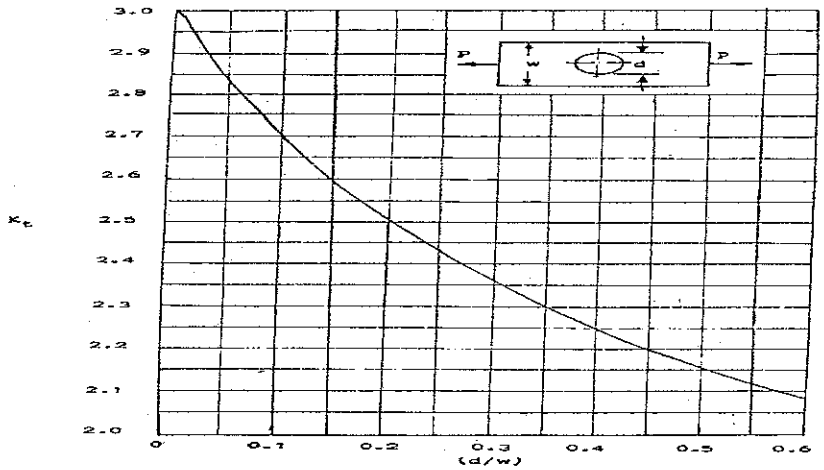


Fig. 5.2 Rectangular plate with transverse hole in tension or compression. (C reproduced by permission of John Wiley & Sons Inc., New York 'Stress Concentration Factors' by R.E. Peterson—1953)

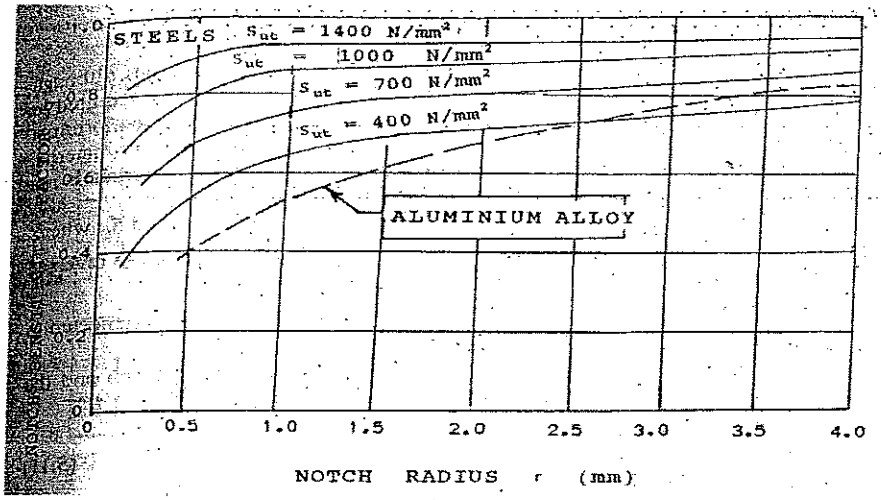
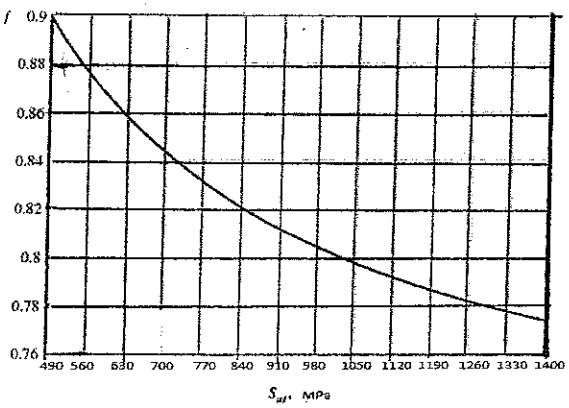


Figure 6–18

Fatigue strength fraction, f, of S_{ut} at 10^3 cycles for $S_e = S'_e = 0.5S_{ut}$.



ANSWERS' SCHEME Qn 1

Solution

$r = \frac{1.5}{2} = 0.75\ m = 750\ mm$

$T_1 = 5.4\ KN = 5400\ N$

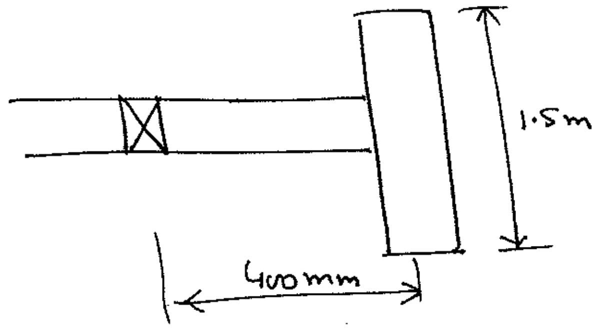
$T_2 = 1.8\ KN = 1800\ N$

$l = 400\ mm$

$d = ?$

$\tau = 42\ Mpa$

$\sigma_b = 86\ Mpa$



$T = (T_1 - T_2) r = (5400 - 1800) 750 = 27 \times 10^5\ N\text{-}mm$

$M = (T_1 + T_2 + W) l = (5400 + 1800) 400 = 28.8 \times 10^5\ N\text{-}mm$

Maximum Shear stress theory

$$T_e = \sqrt{M^2 + T^2} = \frac{\pi}{16} d^3 \tau$$

$$\sqrt{(27 \times 10^5)^2 + (28.8 \times 10^5)^2} = \frac{\pi}{16} d^3 \times 42$$

$d = 77.899\ mm$

Say 78 mm

Maximum Normal stress theory

$$M_e = \frac{1}{2}\left[M + \sqrt{M^2 + T^2}\right] = \frac{\pi}{32} d^3 \sigma_b$$

$$\frac{1}{2}\left[27 \times 10^5 + \sqrt{(27 \times 10^5)^2 + (28.8 \times 10^5)^2}\right] = \frac{\pi}{32} d^3\, 86$$

$d = 72.98$

Say 73 mm

∵ Taking the larger of the two values we have

$d = 78\ mm$ Answer

Solution

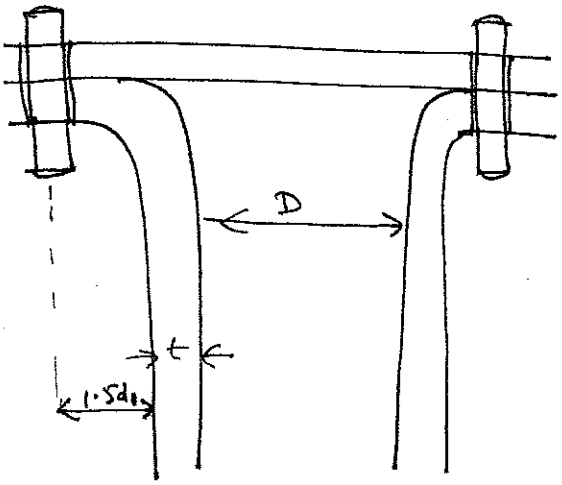
Qun 2

$p = 1.2\ MPa = 1.2\ N/mm^2$

$n = 12$

$D = 300\ mm$

$\sigma_t = 100\ MPa$

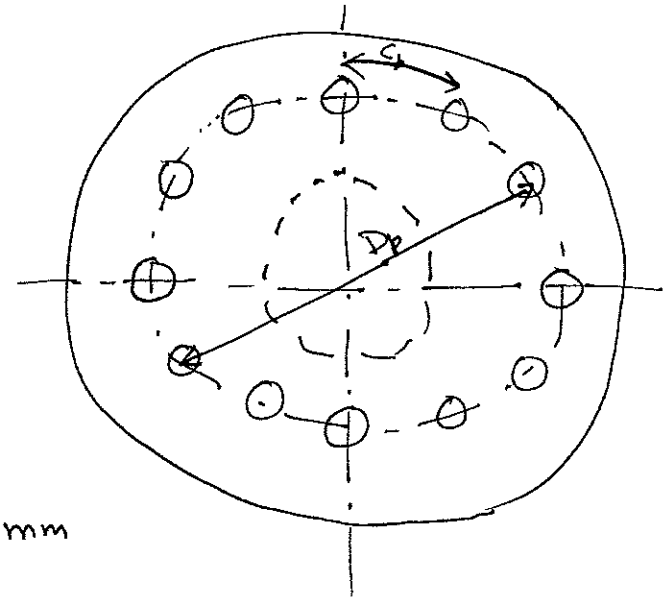


$$F = \frac{\pi}{4} D^2 \times p / n \quad \text{— (1)}$$

$$F = \frac{\pi}{4} d_c^2 \times \sigma_t \quad \text{— (2)}$$

Equating both (1) & (2)

$$\frac{\frac{\pi}{4} D^2 \times p}{n} = \frac{\pi}{4} d_c^2 \times \sigma_t$$



$$D^2 \times p = d_c^2 \times \sigma_t \times n$$

$$\therefore 300^2 \times 1.2 = d_c^2 \times 100 \times 12$$

$$\therefore d_c = 9.48\ mm$$

$$\therefore d = \frac{d_c}{0.85} = 11.16\ mm \qquad \text{Say } 12\ mm$$

$\therefore$ M12 size of stud will be used

Justification :-

$$D_p = D + 2t + 3d_1$$

$$d_1 = d + 1 = 12 + 1 = 13\ mm$$

$$\therefore D_p = 300 + (2 \times 10) + (3 \times 13)$$

$$= 359\ mm$$

$$C_p = \frac{\pi D_p}{n} = \frac{3.14 \times 359}{12} = 93.94\ mm$$

For leak proof joints C_p should be between $20\sqrt{d_1}$ to $30\sqrt{d_1}$.

$20\sqrt{13}$ to $30\sqrt{13}$

72.11 mm to 108.16

Question no 3

Solution

$d_m = 36mm$

$p = 6mm$

$n = 1$

$d_m = d - \frac{p}{2}$

$= 36 - 3 = 33mm$

$l = np = 1 \times 6 = 6mm$

$F = 7.5KN$

$f = 0.15$

$f_c = 0.20$

$d_c = 40mm$

$$T_R = \frac{Fdm}{2}\left(\frac{l + \pi f dm}{\pi dm - fl}\right) + \frac{F f_c d_c}{2}$$

$$= \frac{7.5 \times 1000 \times 33}{2}\left(\frac{6 + \pi \times 0.15 \times 33}{3.14 \times 33 - 0.15 \times 6}\right) + \frac{7.5 \times 1000 \times 0.20 \times 40}{2}$$

$$= 55953.53 \text{ N-mm}$$

$$T_L = \frac{Fdm}{2}\left(\frac{\pi f dm - l}{\pi dm + fl}\right) + \frac{F f_c d_c}{2}$$

$$= \frac{7.5 \times 1000 \times 33}{2}\left(\frac{\pi \times 0.15 \times 33 - 6}{\pi \times 33 + 0.15 \times 6}\right) + \frac{7.5 \times 1000 \times 0.20 \times 40}{2}$$

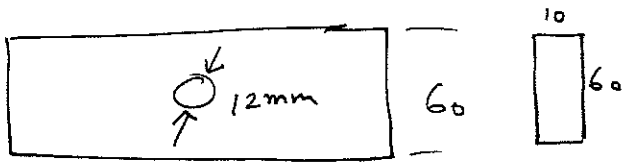
$$= 41298.75 \text{ N-mm}$$

$$e = \frac{Fl}{2\pi T_R} = \frac{7.5 \times 1000 \times 6}{2 \times \pi \times 55953.53} = 0.128$$

$e\% = 12.8\%$

AISI 1018 cold drawn

QUESTION 4



$n_f = 1.8$

$F_a = ?$

$$F_a = \frac{S_e \times A}{n_f \times K_f}$$

$S_{ut} = 440$ Mpa from Table A-20

$\therefore S_e' = 0.5 S_{ut} = 220$ Mpa

$K_a = a S_{ut}^{\,b} = 4.51 (220)^{-0.265} = 0.899$

$K_b = 1$ (axial loading)

$K_c = 0.85$ (axial loading)

$\therefore S_e = 0.899 \times 1 \times 0.85 \times 220 = 168.1$ Mpa

$A = 10 \times (60 - 12) = 480$ mm

$K_f = 1 + q(K_t - 1)$

$= 1 + 0.82 (2.5 - 1) = 2.23$

$\therefore F_a = 20100$ N (by putting the values in eq.

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE PILANI, DUBAI CAMPUS

II SEMESTER 2012-2013

TEST No.1 (Open Book)

Year : II-MECHANICAL	**Section: 1 and 2**	**Date : 11.03.2013**
Course No. : ME F241	**Course Title : Machine Design & Drawing**	
Duration : 50 minutes	**Marks: 40**	**Weightage : 20 %**

Notes: (i) *Answer all the questions*

(ii) *Marks are shown in the brackets against each question*

(iii) Text book and hand-written class notes are only allowed

(iv) Mohr's circles should be drawn to scale on the answer script itself.

Question 1

Using suitable scale for the plane stress stated below, draw Mohr's circle diagram properly labeled to indicate salient points and find the principal stresses, maximum shear stress and the angle of inclination of principal planes.

(a) σ_x = 18 MPa, σ_x = -8 MPa, τ_{xy} = 10 MPa cw **[10M]**

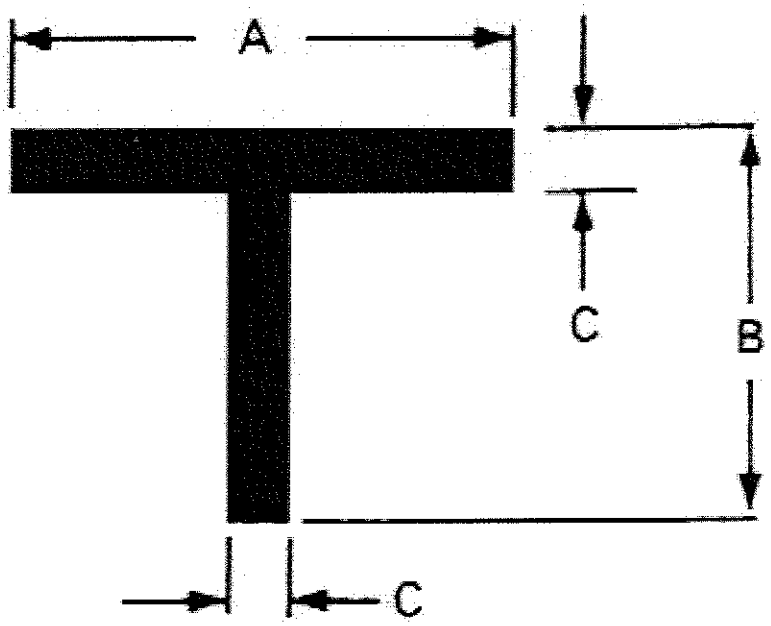
(b) σ_x = 12 MPa, σ_x = 24 MPa, τ_{xy} = 8 MPa, ccw **[10M]**

Question 2

Find the maximum torque transmitted by a solid steel shaft of 40 mm diameter if the shear stress and polar modulus are 60 MPa and 90 GPa respectively. Find also the maximum torque transmitted if this shaft is made hollow with outer and inner diameters as 40 mm and 30 mm respectively. **[8M]**

Question 3

A beam having a T section with the dimensions shown in the figure below is subjected to a bending moment of 1400 N.m about the negative z-axis,that causes tension and compression on the top and bottom surfaces respectively. Locate the neutral axis and find the maximum tensile and compressive bending stresses. **[12M]**



A = 70 mm, B = 110 mm and C = 12 mm

BITS PILANI, Dubai Campus

II Sem 2012-13

ME F241 Machine Design & Drawing

TEST-1 (Open Book)

Date: 11-03-13 | Marks: 40

Time: 50 minutes | ANSWERS' scheme | Weightage: 20%

Question 1

(a) & (b)

Mohr's circle ——— [5 M]

Scale ——— [1 M]

Solve for principle stresses ——— [2 M]

Values for principle stresses, max. shear stress & angle ——— [4 × ½ = 2 M]

[10 M] × 2

= [20 M]

Q2

Solid shaft

Torque ——— [3 M]

Hollow shaft

Torque ——— [5 M]

TOTAL [8 M]

BITS PILANI, Dubai Campus

II Sem 2012-13

ME F241 Machine Design & Drawing

TEST-1 (Open Book)

Date: 11-03-13 Marks: 40

Time: 50 minutes ANSWERS' scheme Weightage: 20%

Question 1

(a) & (b)

Mohr's circle ——— [5M]

Scale ——— [1M]

Salient pts ——— [2M]

Values for principle stresses, max. shear stress & angle } ——— [4×½ = 2M]

[10M] × 2

= [20M]

Q2

Solid shaft

Torque ——— [3M]

Hollow shaft

Torque ——— [5M]

TOTAL [8M]

Question 3

Locating Neutral axes ---------- [3M]

Finding M.I of Composite section ---------- [5M]

Finding stresses ---------- [4M]

TOTAL : [12M]

Question 3

Locating Neutral axis ---------- [3M]

Finding M.I of composite section ---------- [5M]

Finding stresses ---------- [4M]

TOTAL : [12M]