

**BITS, PILANI-DUBAI, INTERNATIONAL ACADEMIC CITY, DUBAI
FIRST SEMESTER 2007-2008**

COMPREHENSIVE EXAMINATION

Course Name: Design of Machine Elements
Course No. : ME UC312
Duration : 3 Hours

Max Marks: 40
Weightage: 40%
Date: 06-01-2008

- NOTE:**
- i) Write your ID Number on the top immediately on the receipt of this paper.
 - ii) Attempt all the questions.
 - iii) Required values, tables & charts are given in the paper.
 - iv) Personal data table & charts are not allowed in the examination hall.
 - v) If any data is missing, assume the suitable value with proper justification.
 - vi) Description of symbols & notations is necessary for formulae used.

Q.1

- (a) Define the Engineering Design and explain the elements of Design Process. **(Marks=1+1)**
- (b) A steel specimen shown in figure -1, used by SAE laboratory to performed standard tension test on UTM for evaluating several mechanical properties.

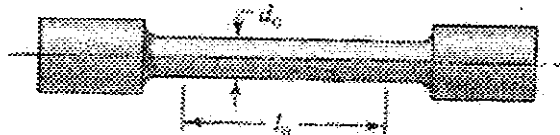


Figure-1

The dimensions of the specimen and observations made during the test are described below. **(Marks: 0.5X8=4)**

Diameter of the specimen $d_0 = 12.5$ mm
Gauge length $l_0 = 62.5$ mm
Load at upper yield point = 42.5 KN
Load at lower yield point = 41.0 KN
Maximum load = 72.5 KN
Fracture load = 51.25 KN
Gauge length at fracture = 80.5 mm
Diameter of fracture section = 9.5 mm
Strain at a load of 20 KN = 7.764×10^{-6} mm/mm.

Determine:

- (i) The yield strength
- (ii) The Ultimate Strength
- (iii) The % Elongation in length
- (iv) The % Reduction in Area
- (v) Modulus of toughness
- (vi) Modulus of resilience
- (vii) Modulus of elasticity
- (viii) Fracture Stress

Q.2

- (a) Describe the Miners rule for cumulative fatigue damage. **(Marks: 1)**

P.T.O

- (b) A beam of circular section reduces in dia. from 100 mm to 90 mm over a transition radius of 5.0 mm shown in figure-2. The beam is subjected to a bending moment which fluctuates between M_{min} 1 kN-m to $M_{max} = 3$ kN-m. If beam is made of ground finish annealed steel with following properties $S_{ut} = 480$ MPa, $S'_e = 210$ MPa, BHN=190. Show is the beam is safe or not.

(Marks: 3)

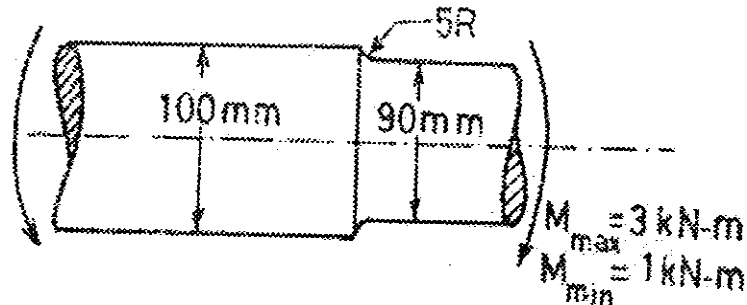


Figure-2

Assume following:

F or Surface Modification Factor	$a = 1.58$ & $b = 0.086$
Size Modification factor	$K_b = 0.85$
Temperature Modification factor	$K_d = 1$
Miscellaneous Effect Modification factor K_e	$= 1/K_f$

Q.3

- (a) What is the effect of initial tightening in bolts?

(Marks: 1)

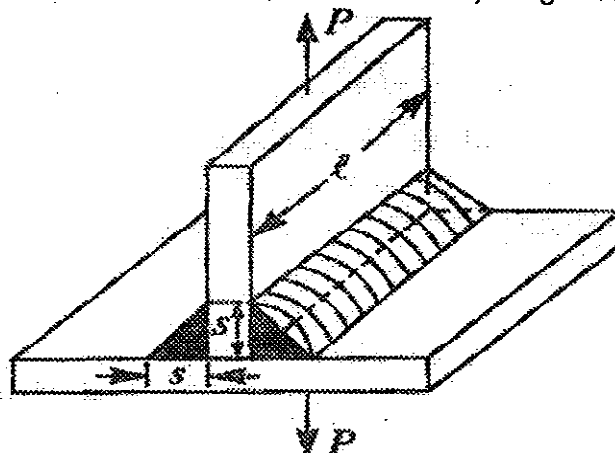
- (b) An air compressor cylinder of effective diameter 300 mm is subjected to air Pressure of 1.5 N/mm². The cylinder head is connected by means of 8 bolts having yield strength of 350 N/mm² and endurance limit of 240 N/mm². The bolts are tightened with an initial pre-load force of 1.5 times that of the external force. A copper gasket (gasket factor $C=0.25$) is used to make the joint leak proof. Assume stress concentration factor of 2.5 and factor of safety of 2. Determine the required size of the bolt.

(Marks: 3)

Q.4

- The fillet welds of equal legs are used to fabricate a T as shown in figure -3 where S is the leg size and l is the length of the weld. Locate the plane of maximum shear stress for the loading patterns i.e. load at right angles to the weld (transverse load). Neglect the effect of eccentricity.

Figure-3



(Marks: 3)

Q.5

- (a) Enumerate the procedure for selection of antifriction bearings from manufacturer's catalogue and also elaborate the different formulae used for the same.
- (b) Explain the term "Rated Life" with reference to ball bearings.

(Marks: 2)

(Marks: 1)

Q.6

(a) What is meant by surge in springs? (Marks: 1)

(b) Design & draw a valve spring of a petrol engine for the following operating conditions: (Marks: 3)

Length of spring when the valve is open	= 40 mm.
Length of spring when the valve is closed	= 50 mm.
Spring load when valve is open	= 400 N.
Spring Load when Valve is closed	= 200 N.
Maximum inside diameter of the spring	= 28 mm.
Maximum permissible shearing stress	= 400 MPa.
Modulus of rigidity	= 80000 MPa

SWG	4	5	6	7	8	9	10	11	12
Dia (mm)	5.893	5.385	4.877	4.470	4.064	3.658	3.251	2.946	2.642

Take the Wahl's K factor for spring index C

$$K = \frac{4C - 1}{4C - 4} + \frac{0.615}{C}$$

Q.7

(a) Discuss the stable & unstable lubrication in journal bearings with the help of Petroff's relation. (Marks: 2)

(b) A water cooled bearing having the following dimensions has operated at 600 rev/min under 9000N load with automobile oil for a number of years without any trouble. The viscosity of this oil at the oil temperature of 50 °C is 0.05 Kg/ms.

Journal diameter = 50 mm.

Bearing Length = 80 mm.

Radial Clearance = 0.025 mm.

(Marks: 2)

It is proposed to use bearings of this design in several new machines which are under design.

- (i) What changes do you recommend if new machine operates at 300 rev/min?
- (ii) What changes do you recommend if new machine operates under 18KN?

Q.8

A gear train transmitting 5 kW at 1440 rpm is shown in the following figure-4. The number of teeth on gears A, B, C, and D are 25, 100, 30, and 150, respectively. All gears have 5 mm module and a 20° full-depth involute profile gear tooth. Calculate the tangential and radial components of forces between gears A and B and between gears C and D. Also calculate the reactions at the bearing supports S1 and S2 due to horizontal forces. (Marks: 3)

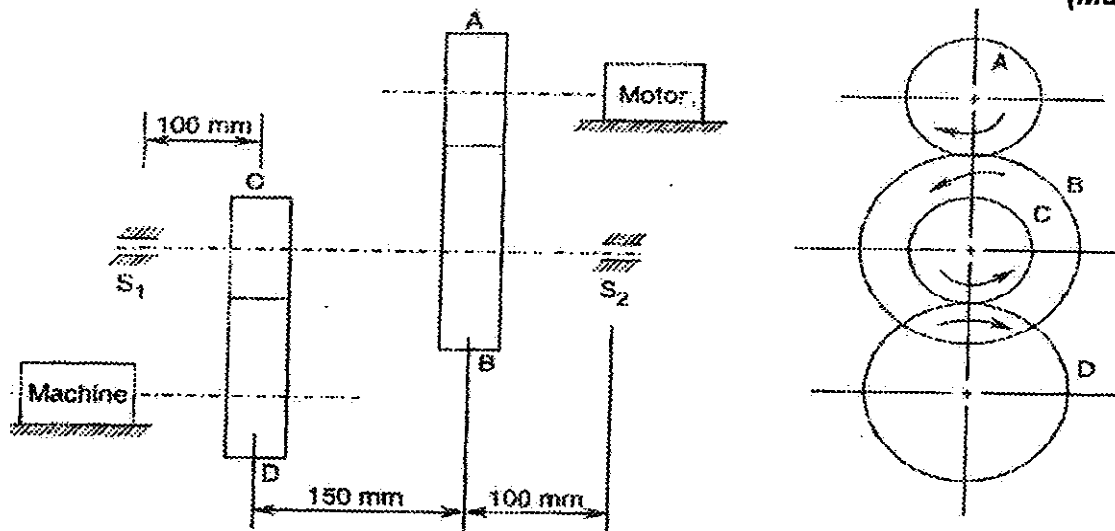


Figure-4

P.T.O

Q.9

An internal expanding brake shown in figure-5 has the arrangement of two brake shoes which act on the internal surface of a cylindrical drum. The braking force F_1 and F_2 are applied as shown in figure-5 and each shoe pivots on its fulcrum O_1 and O_2 . The width of the brake lining is 35 mm; the intensity of pressure at any point A is $0.4 \sin\theta$ N/mm², where θ is measured as shown from either pivot. The coefficient of friction is 0.4. Determine the braking torque and the magnitude of the forces F_1 and F_2 . (Marks: 3)

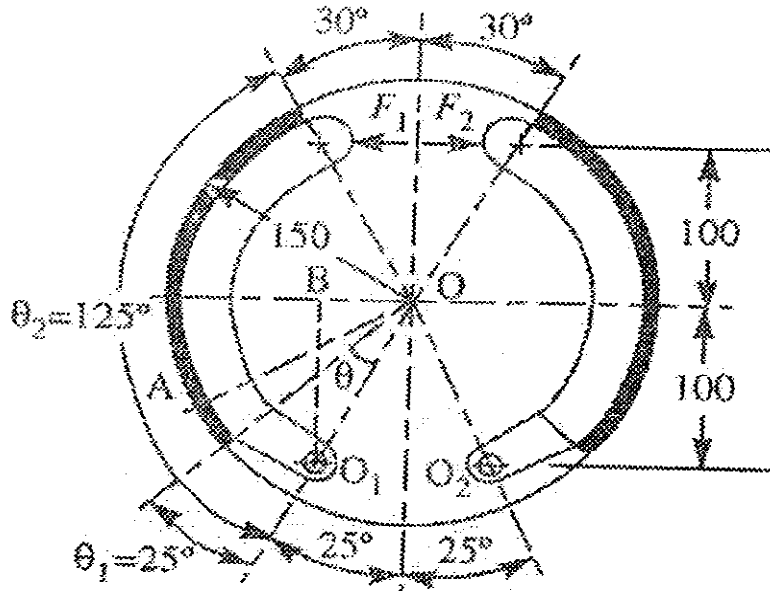


Figure-5

Q.10

(a) Write the name of three flexible machine elements and also give their specific applications. (Marks: 2)

(b) A horizontal nickel steel shaft rests on two bearings, A at the left and B at the right end and carries two gears C and D located at distances of 250 mm and 400 mm respectively from the centre line of the left and right bearings shown in figure-6. The pitch diameter of the gear C is 600 mm and that of gear D is 200 mm. The distance between the centre line of the bearings is 2400 mm. The shaft transmits 20 kW at 120 r.p.m. The power is delivered to the shaft at gear C and is taken out at gear D in such a manner that the tooth load of the gear C and the gear D act vertically downwards.

Find the diameter of the shaft, if the working stress is 100 MPa in tension and 56 MPa in shear. The gear C and D weighs 950 N and 350 N respectively. The combined shock and fatigue factors for bending and torsion may be taken as 1.5 and 1.2 respectively. (Marks: 4)

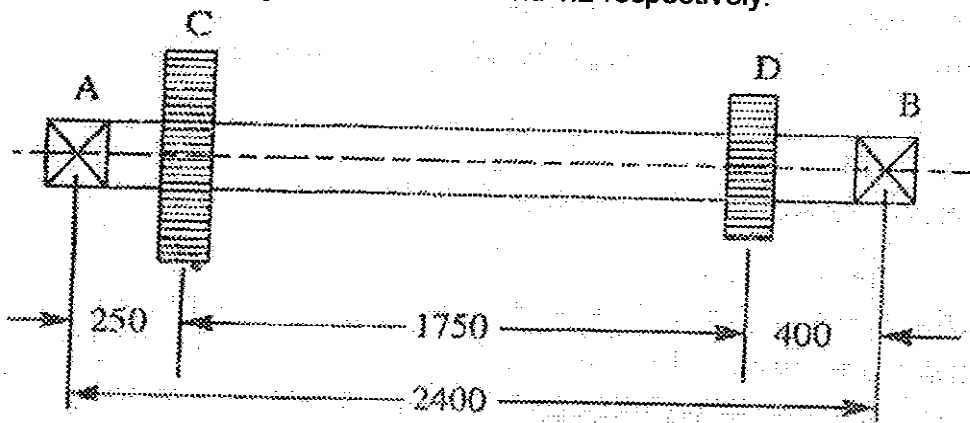
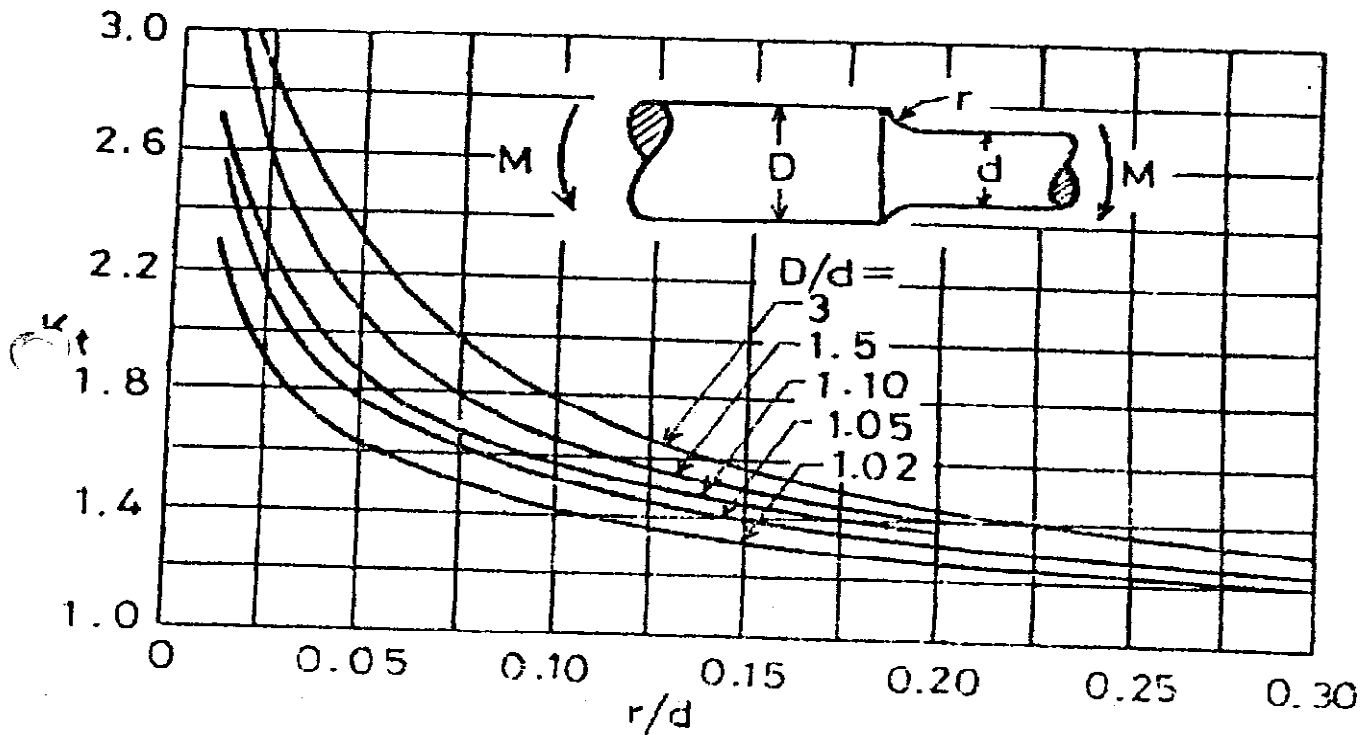
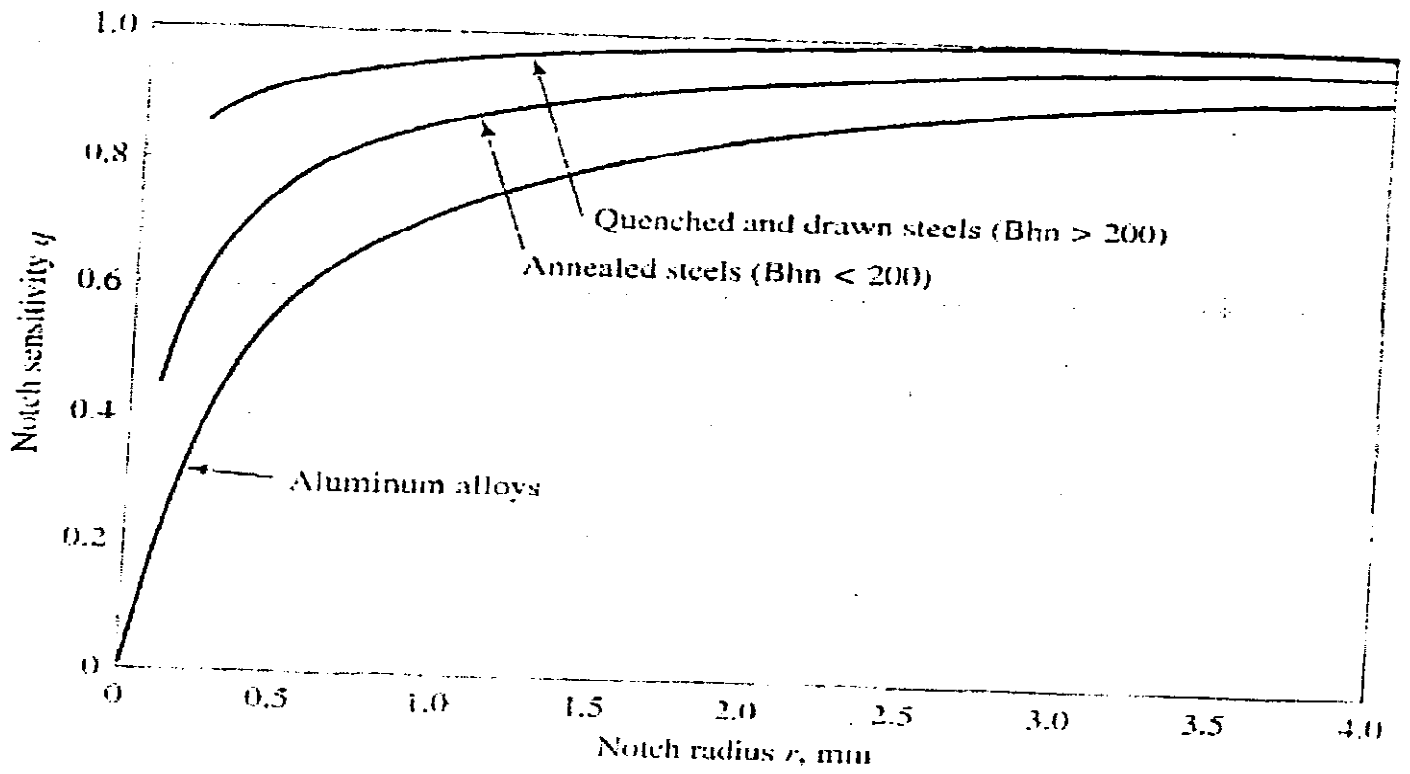


Figure-6



Stress concentration for round bar with shoulder under bending
 $\sigma_{nom} = 32 M / \pi d^3$.

Table ■ Basic dimensions of ISO metric screw threads IS : 4218 (Part III)—1967

Basic diameter (mm)	Pitch (mm)	Major diameter (mm)	Pitch diameter (mm)	Minor diameter (mm)		Lead angle (θ°)	Tensile stress (mm ²)
				External threads	Internal threads		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
10	1.5	10.0	9.025721	8.159696	8.376202	3	58.0
	1	10.0	9.350481	8.773131	8.917468	1	64.5
12	1.5	12.0	11.025721	10.159696	10.376202	2	88.1
	1	12.0	11.350481	10.773131	10.917468	1	96.1
14	1.5	14.0	13.025721	12.159696	12.376202	2	125
	1	14.0	13.350481	12.773131	12.917468	1	134
16	1.5	16.0	15.025721	14.159696	14.376202	1	167
	1	16.0	15.350481	14.773131	14.917468	1	178
18	1.5	18.0	17.025721	16.159696	16.376202	1	216
	1	18.0	17.350481	16.773131	16.917468	1	229
20	1.5	20.0	19.025721	18.159696	18.376202	1	272
	1	20.0	19.350481	18.773131	18.917468	0	285
22	2	22.0	20.700962	19.546261	19.834936	1	318
	1	22.0	21.350481	20.773131	20.917468	0	348
24	2	24.0	22.700962	21.546261	21.834936	1	384
	1	24.0	23.350481	22.773131	22.917468	0	418
25	3	25.0	23.051443	21.319392	21.752405	2	385
27	3	27.0	25.051443	23.319392	23.752405	2	459
	2	27.0	25.700962	24.546261	24.834936	1	496
30	3	30.0	28.051443	26.319392	26.752405	1	581
	2	30.0	28.700962	27.546261	27.834936	1	621
33	3	33.0	31.051443	29.319392	29.752405	1	716
	2	33.0	31.700962	30.546261	30.834936	1	761
35	1.5	35.0	34.025721	33.159696	33.376202	0	886
36	3	36.0	34.051443	32.319392	32.752405	1	865
	2	36.0	34.700962	33.546261	33.834936	1	915
42	4	42.0	39.401924	37.092523	37.669873	1	1150
	3	42.0	40.051443	38.319392	38.752405	1	1210
45	4	45.0	42.401924	40.092523	40.669873	1	1340
	3	45.0	43.051443	41.319392	41.752405	1	1400
48	4	48.0	45.401924	43.092523	43.569873	1	1540
	3	48.0	46.051443	44.319392	44.752405	1	1600
52	4	52.0	49.401924	47.092523	47.669873	1	1830
	3	52.0	50.051443	48.319392	48.752405	1	1900
56	4	56.0	53.401924	51.092523	51.669873	1	2140
	3	56.0	54.051443	52.319392	52.752405	1	2220
60	4	60.0	57.401924	55.092523	55.669873	1	2490
	3	60.0	58.051443	56.319392	56.752405	0	2570

BITS, PILANI-DUBAI, INTERNATIONAL ACADEMIC CITY, DUBAI
FIRST SEMESTER 2007-2008
Open Book Test

Course Name: Design of Machine Elements

MAX MARKS: 20

Course No. : ME UC312

WEIGHTAGE: 20%

Nature of Component: Open Book

Duration: 50 Minutes

NOTE:

- i) Write your ID Number on the top immediately on the receipt of this paper.
- ii) Attempt all the questions.
- iii) If any data is missing, assume suitable value.
- iv) Text Book "Mechanical Engg. Design" J.E Shigley is allowed in Examination Room.
- iv) Hand written class Notes are allowed in Examination Room.
- v) No photo copies of books, class notes & chats are allowed in Examination Room.

Q.1 A single plate clutch is to be designed for a vehicle. Both sides of the plate are to be effective. The clutch transmits 30 kW at a speed of 3000 r.p.m. and should cater for an over load of 20%. The intensity of pressure on the friction surface should not exceed 0.085 N/mm² and the surface speed at the mean radius should be limited to 2300 m /min. The outside diameter of the surfaces may be assumed as 1.3 times the inside diameter and the coefficient of friction for the surfaces may be taken as 0.3. If the axial thrust is to be provided by six springs of about 25 mm mean coil diameter, design the springs selecting wire from the standard wire gauge data.

(Marks: 10)

& take the following:

Sq. end with number of active coil

= 8

Allowable shear stress (spring wire material)

= 420MPa.

Modulus of rigidity (spring wire material)

= 84 KNmm²

SWG	4	5	6	7	8	9	10	11	12
Dia (mm)	5.893	5.385	4.877	4.470	4.064	3.658	3.251	2.946	2.642

Q.2 The fillet welds of equal legs are used to fabricate a T as shown in figure -1 where S is the leg size and l is the length of the weld. Locate the plane of maximum shear stress for the loading pattern i.e. load is parallel to the weld. Neglect the effect of eccentricity.

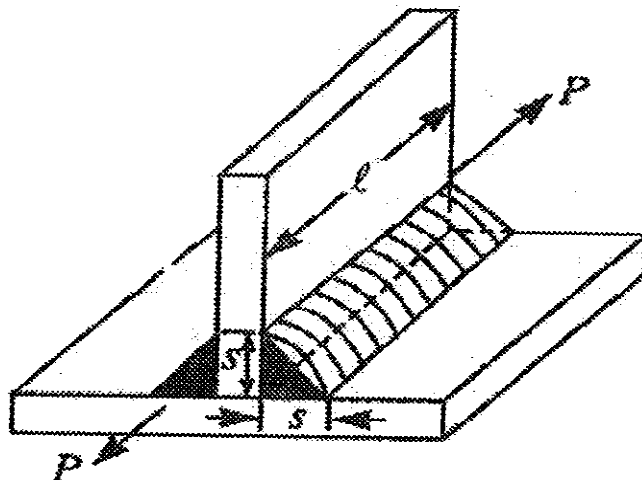
(Marks: 10)

Figure-1

**BITS, PILANI-DUBAI, INTERNATIONAL ACADEMIC CITY, DUBAI
FIRST SEMESTER 2007-2008**

TEST-I

Course Name : Design of Machine Elements

MAX MARKS: 25

Course No. : ME UC312

WEIGHTAGE: 25%

Nature of Component : Closed Book

Duration : 50 Minutes

- NOTE:**
- i) Write your ID Number on the top immediately on the receipt of this paper.
 - ii) Attempt all the questions.
 - iii) If any data is missing, assume suitable value.
 - iv) Use the tables & charts, enclosed herewith, wherever necessary.
 - v) Outside data table & charts are not allowed in the examination hall.

Q.1

- (a) Briefly explain the Phases of Design Process. (Marks=2)
- (b) Enumerate the factors and the properties of materials, a designer is required to consider while designing a machine element. (Marks=2)
- (c) Define the following terms related to screw fastenings:
 (i) Major & Minor Diameter (ii) Pitch (iii) Multi start (Marks:1+1+1= 3)

Q.2

(a) A steel specimen is tested in a standard tension test to evaluate several mechanical properties. The dimensions of the specimen and observations made during the test are described below. (Marks: 1+1+1+1=4)

Diameter of the specimen = 12.5 mm

Gauge length = 62.5 mm

Load at upper yield point = 42.5 KN

Load at lower yield point = 41.0 KN

Maximum load = 72.5 KN

Fracture load = 51.25 KN

Gauge length at fracture = 80.5 mm

Diameter of fracture section = 9.5 mm

Strain at a load of 20 KN = 7.764×10^{-6} mm/mm.

Determine:

- (i) The yield strength (ii) The % elongation (iii) modulus of elasticity (iv) modulus of resilience
- (b) A bolt is C15 having 200 N/mm^2 yield strength subjected to a direct load of X KN and shear load of Y kN. Determine a suitable size of the bolt, according to
- i) Maximum Principal Stress theory. (Marks: 2+2+2=6)
 - ii) Maximum shear stress theory.
 - iii) Maximum strain Energy theory.

Take Value of X = Year of your date of birth -1957
 Value of Y = (Year of your date of birth -1947)/2
 FOS = 2.0

Q.3 A steel plate 52 mm wide and 15 mm thick as shown in figure-1 changes in width to 40mm over a transition radius of 5 mm. The plate is subjected to axial fluctuating load varying between 5F and 2 F. The steel plate is heat treated to have tensile strength of 920 N/mm² and yield strength of 750 N/mm². Assume notch sensitivity index of 0.9 and that the notch is ground finished. Also assume that there is no effect of size in case of plate. Calculate the load that can be applied in the fluctuating cycle.

If a residual stress, compressive in nature, equal to 50% of yield strength is induced in the region of stress concentration what max. and min. loads can be applied ?

Also calculate the max. Static load that will not cause yielding.

(Marks: 3+3+2=8)

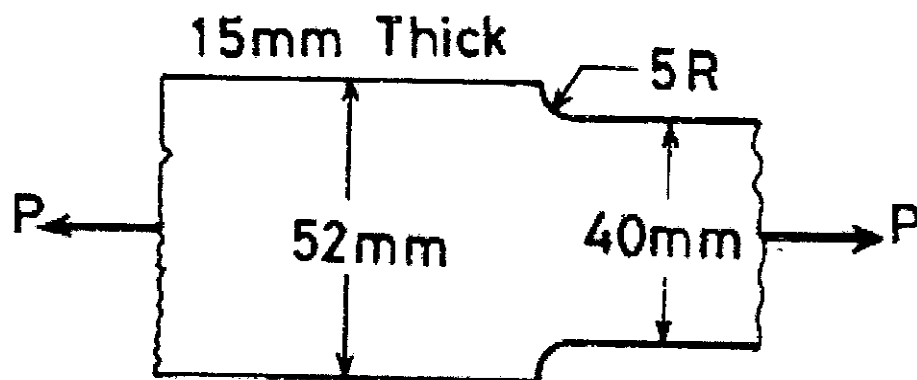
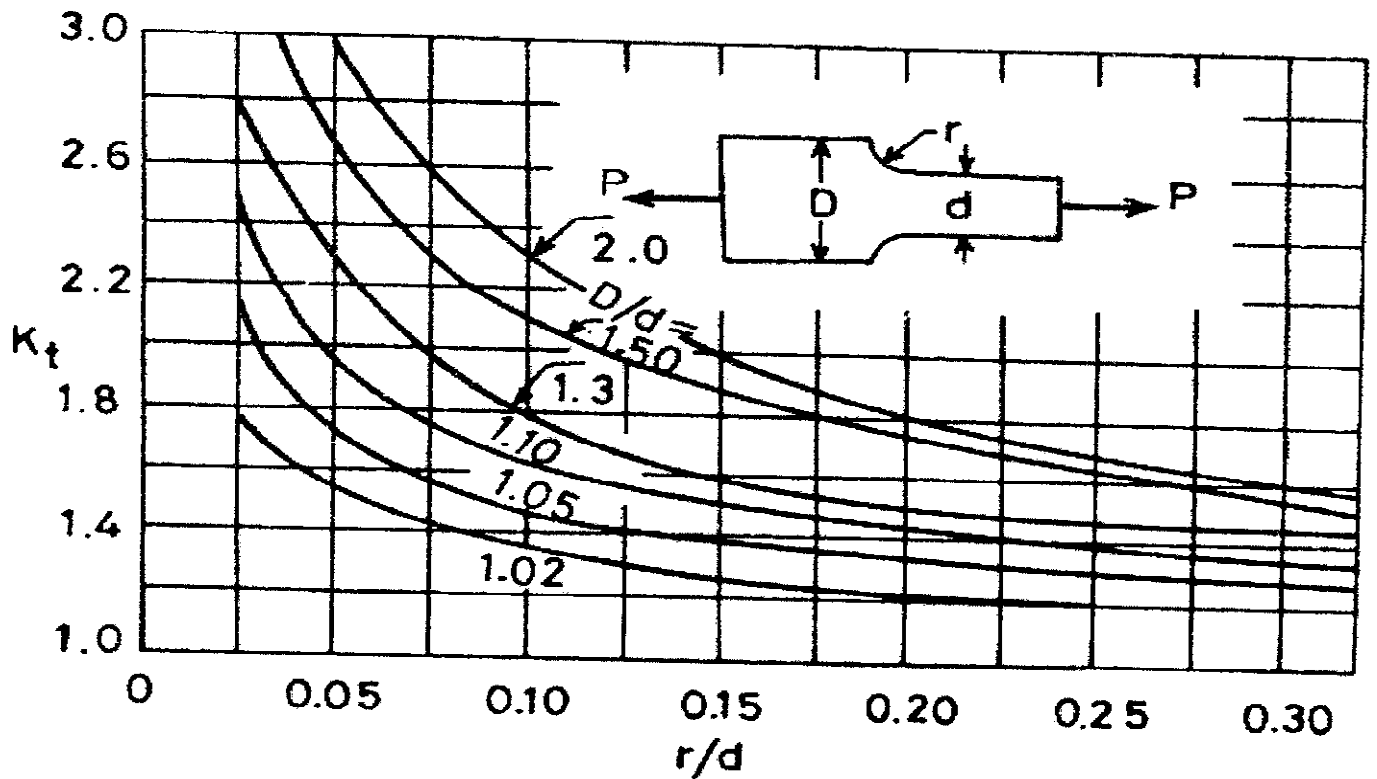


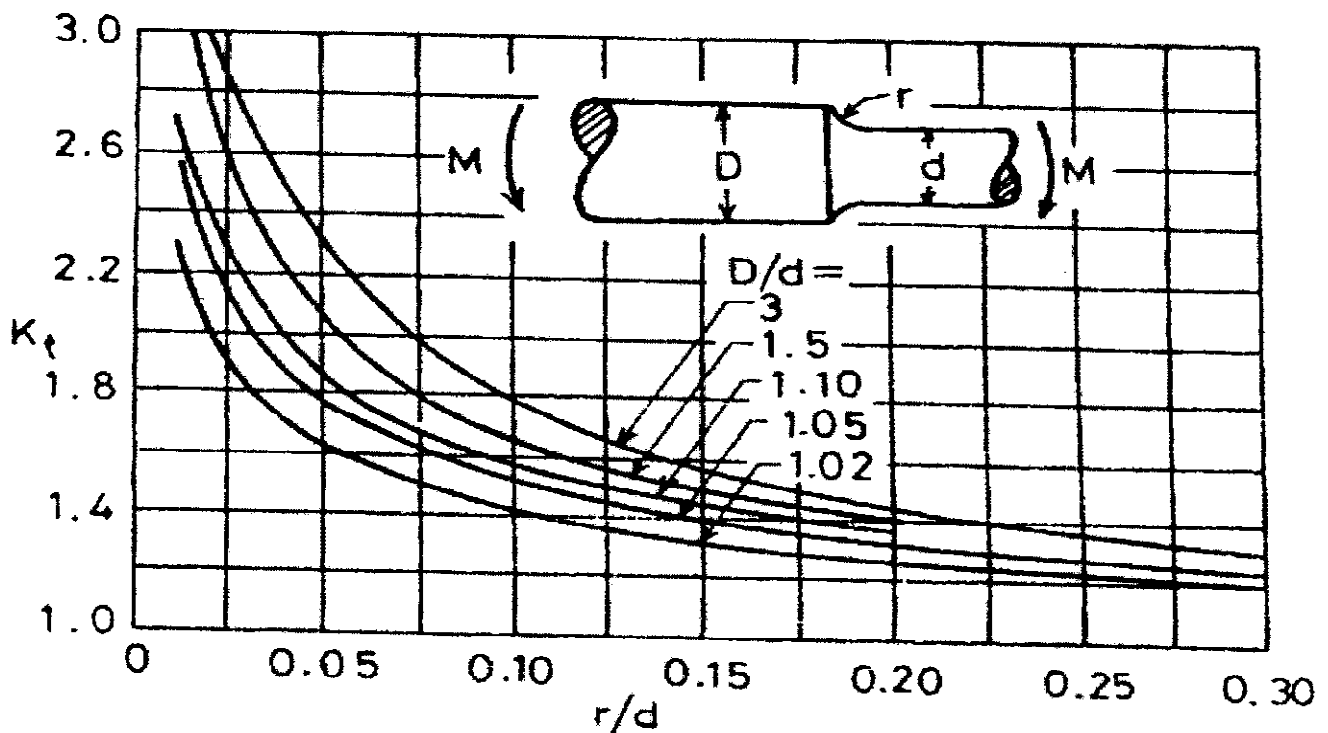
Figure-1

Take The following:

Surface Modification Factor	K_a	= 1
Size Modification factor	K_b	= 1
Load Modification factor	K_c	= $1.43[S_{ut}]^{-0.0778}$
Temperature Modification factor	K_d	= 1
Miscellaneous Effect Modification factor	K_e	= $1/K_f$
Factor of safety	n	= 1.3



Stress concentration factor for rectangular filled bar in axial tension or compression $\sigma_{nom} = P/dt$ where $t =$ thickness.



Stress concentration for round bar with shoulder under bending $\sigma_{nom} = 32 M/\pi d^3$.

BITS, PILANI-DUBAI, INTERNATIONAL ACADEMIC CITY, DUBAI
FIRST SEMESTER 2007-2008
ME UC 312 DESIGN OF MACHINE ELEMENTS (QUIZ-I)

MAX MARKS: 15
DURATION: 15 MINUTES

WEIGHTAGE: 5%
DATE: 01-10-2007

NAME OF STUDENT: _____ I.D: _____

NOTES: i) Change of answer & overwriting is not permitted.
 ii) If any one found in signal nodding or any form of cheating, his copy
 will be marked by # and then forwarded to discipline committee for further action.

- Q.1 A theory of failure is necessary when a component is subjected to? (Marks: 1)
Ans:
- Q.2 What is the most important design consideration is? (Marks: 1)
Ans:
- Q.3 Which is the best theory of failure for brittle material? (Marks: 0.5)
Ans:
- Q.4 Stress concentration occurs due to what? (Marks: 0.5)
Ans:
- Q.5 What is modulus of resilience? (Marks: 0.5)
Ans:
- Q.6 What is the relation between E, G & K for homogenous, isotropic & elastic material?
(Marks: 1)
Ans:
- Q.7 What is the measure of ductility? (Marks: 1)
Ans:
- Q.8 The cup & cone failure result occur in which material? (Marks: 0.5)
Ans:
- Q.9 Why Molybdenum is added in steels ? (Marks: 1)
Ans:
- Q.10 The modulus of elasticity & Poisson's ratio of a material are 2.1 unit & 0.3 respectively. what is the value of modulus of rigidity for the same material? (Marks: 1.5)
Ans:
- Q.11. What is the radius of Mohr's Circle? (Marks: 1)
Ans:
- Q.12 The original angle of 90 square changes to $90+\gamma$, what is the shearing strain is? (Marks: 1)
Ans:
- Q.13 Describe the state of stress at any point in the cross-section of a prismatic bar subjected to axial load P along X-axis, having cross-sectional area of the bar as A. (Marks: 1.5)
Ans:
- Q.14 If hole of diameter 'd' is punched in a metal of thickness 't' then what force is required to punch a hole? (Marks: 1.5)
Ans:
- Q.15 A solid shaft transmits a torque T, the allowable shear stress is τ . what is the diameter of the shaft? (Marks: 1.5)
Ans:

BITS, PILANI-DUBAI, INTERNATIONAL ACADEMIC CITY, DUBAI
FIRST SEMESTER 2007-2008
ME UC 312 DESIGN OF MACHINE ELEMENTS

QUIZ-3

MAX MARKS: 05
DURATION: 15 MINUTES

WEIGHTAGE: 5%
DATES: 28/11/07

NAME OF STUDENT: _____

I.D: _____

NOTES: i) Change of answer & overwriting is not permitted.
ii) If any one found in signal nodding or any form of cheating, his copy
will be marked by # and then forwarded to discipline committee for further action.

Q.1 What is the value of contact angle in case of full journal bearing? ((Marks: 0.5)

Ans:

Q.2 Define the bearing characteristic number ((Marks: 0.5)

Ans:

Q.3 Which material is generally used for clutch friction lining? (Marks: 0.5)

Ans:

Q.4 Write the axial force equation for engaging the cone clutch? (Marks: 0.5)

Ans:

Q.5 Write the name of brake commonly used in railway trains? (Marks: 0.5)

Ans:

Q.6 Two closed coil springs with stiffness K_1 & K_2 respectively are connected in series. What will be the equivalent stiffness? (Marks: 0.5)

Ans:

Q.7 Draw the Diagram of internal expanding brakes & mark the following on the same figure.
(i) Brake Lining (ii) cam (iii) Leading Shoe (iv) secondary shoe. (Marks :1+1)

(Use the back side of paper)

BITS, PILANI-DUBAI, INTERNATIONAL ACADEMIC CITY, DUBAI
FIRST SEMESTER 2007-2008
ME UC 312 DESIGN OF MACHINE ELEMENTS

QUIZ-4

MAX MARKS: 05
DURATION: 15 MINUTES

WEIGHTAGE: 5%
DATES: 12/12/07

NAME OF STUDENT: _____

I.D: _____

NOTES: i) Change of answer & overwriting is not permitted.
 ii) If any one found in signal nodding or any form of cheating, his copy
 will be marked by # and then forwarded to discipline committee for further action.

Q.1 What is counter shaft? (Marks: 0.5)

Ans:

Q.2 What is the most preferable method of shaft manufacturing? (Marks: 0.5)

Ans:

Q.3 "Shafts are designed on the basis of strength". This statement is true or false?
(Marks: 0.5)

Ans:

Q.4 "Shafts are designed on the basis of rigidity". This statement is true or false?
(Marks: 0.5)

Ans:

Q.5 A shaft is subjected is torsion only, Draw its shear stress variation along the radius.
(Marks: 0.5)

Ans:

Q.6 "For the same length, material & weight the strength of hollow shaft is more than solid shaft". This statement is true or false?
(Marks: 0.5)

Ans:

Q.7 Two shaft A & B are of the same length & material. If the diameter of the shaft A is three times of shaft B, what will be the ratio torsional stiffness of shaft A & B.
(Marks: 2.0)