MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION
(Autonomous)

(ISO/IEC - 27001 - 2005 Certified)

Summer – 2015 EXAMINATION

Subject Code: **17525**

Model Answer

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.

2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.

3) The language errors such as grammatical, spelling errors should not be given more importance. (Not applicable for subject English and Communication Skills).

4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.

5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.

6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidate's understanding.

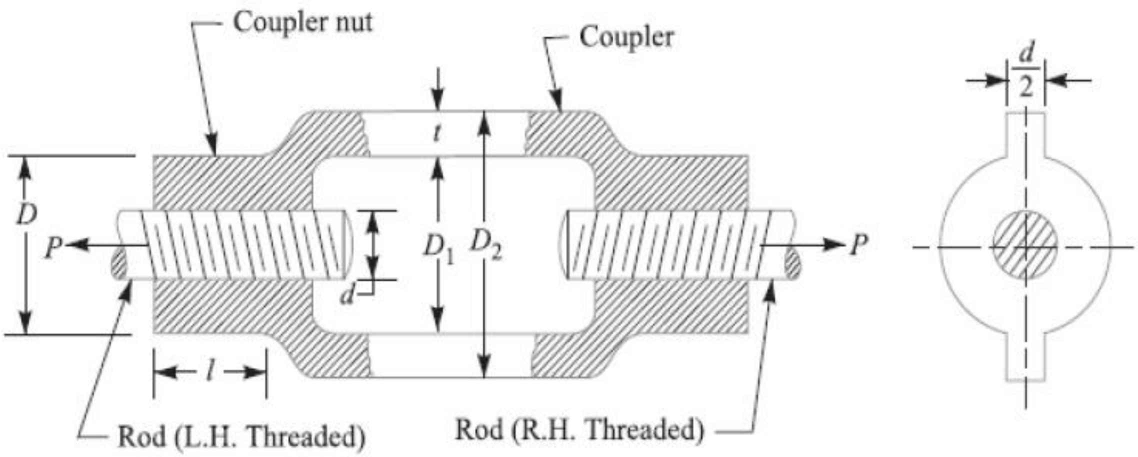
7) For programming language papers, credit may be given to any other program based on equivalent concept.

……

	Marks
1. A) Attempt any THREE	**12**
a) List the important factors that influence the magnitude of factor of safety.	04
Answer : ***(Any Four – 1 Marks Each)*** **The factors that influence the magnitude of factor of safety:** 1. The reliability of applied load and nature of load, 2. The reliability of the properties of material and change of these properties during service, 3. The reliability of test results & accuracy of application of these results to actual machine parts, 4. The certainty as to exact mode of failure, 5. The extent of simplifying assumptions, 6. The extent of localized stresses, 7. The extent of initial stresses setup during manufacture, 8. The extent of loss of property if failure occurs, 9. The extent of loss of life if failure occurs.	04
b) Define the following properties of a material: i) Creep ii) Ductility	04
Answer:	
Creep: If the metal is subjected to a constant load at high temperature for a long period of time, then it will undergo slow and permanent deformation called creep.	02
Ductility: It is the property of material enabling it to be drawn into thin wires with application of tension force.	02
c) Mention the materials and applications of the following joints : i) Knuckle joint ii) Spigot and socket joint.	04
Answer: ***(Material – 01 Mark and Applications any two - ½ Marks Each)*** **Knuckle joint:**	
Material: Steel or wrought iron.	01

Applications: (any two) 1. It is used in link of cycle chain, 2. It is used in tie rod joints for roof truss, 3. It is used in valve rod joint for electric rod, 4. It is used in pump rod joint, 5. It is used in tension link in bridge structure, 6. It is used in lever and rod connection of various types. **Spigot and socket joint:** **Material:** Wrought iron or mild steel. **Applications: (any two)** 1. It is used in connecting a piston rod to cross head of steam engine, 2. It is used in joining a tail rod with piston rod of an air pump, 3. It is used in valve rod and its stem.	01 01 01
d) Why propeller shaft are generally made hollow?	04
Answer: ***(Credit should be given to any Equivalent explanation)*** Propeller shafts of road vehicles are sufficiently long and operate at high speed. Consequently, whirling may occur at certain critical speed. This causes bending stresses in material that are higher than shearing stress caused by transmitted torque. The tendency for a propeller shaft to whirl should be reduced. The critical speed of shaft increases with decrease in weight. Hence propeller shafts are made hollow which increases the moment of inertia of section and keeps the weight minimum.	04
B) Attempt any ONE of the following :	06
a) Design a hollow propeller shaft of a car with outside diameter 75 mm, transmits 22.5kw at 1500 rpm to the wheels which are 90 cm in diameter. If the allowable shear stress is 60 N/mm^2. Find out inner and outer diameter of shaft. Take gear box reduction as 5.	06
Answer: Given : $d_0 = 75\text{mm}$ $f_s = 60\text{N/mm}^2$ $P = 22.5\text{kW} = 22.5\times10^3\,\text{W}$ Gear reduction $G_1 = 5$ Now, torque produced by the engine $'T_e'$ $P = \dfrac{2\pi\,N\,T_e}{60}$ $22.5\times10^3 = \dfrac{2\times3.14\times1500\times T_e}{60}$	01

$T_e = 143.24 \text{ N} - \text{m}$ $T_e = 143.24 \times 10^3 \text{ N-mm}$	01
Now torque transmitted by the propeller shaft $'T_P'$ $T_P = T_e \times G_1$ $= 143.24 \times 10^3 \times 5$ $T_P = 716.2 \times 10^3 \text{ N-mm}$	01
For hollow shaft Let, $d_0 =$ outer diameter of shaft $d_i =$ inner diameter of shaft $k = \frac{d_i}{d_0} = \frac{d_i}{75}$ We know that $T_P = \frac{\pi}{16} f_s (d_0)^3 (1-k^4)$ $716.2 \times 10^3 = \frac{3.14}{16} \times 60 \times (75)^3 (1-k^4)$	01
$1-k^4 = 0.14$ $k^4 = 0.855$ $\frac{(d_i)^4}{(75)^4} = 0.855$ $d_i = 72.1 \text{ mm} \ldots\ldots\ldots\ldots\ldots\ldots = d_i = 72 \text{ mm}$	02
b) Draw a neat sketch of turn buckle joint. Design the turn buckle tie rod diameter only to withstand a load 2000 N. Permissible stresses are ft = 70 N/mm^2, fs = 60 N/mm$^{2.}$	06
Answer: Given, P=2000 N, ft =70 N/mm^2, fs = 60 N/mm^2 Design load P_d = 1.3 P = 1.3 x 2000 = 2600 N Let , Core diameter of rod = dc	01



03

Figure. Turn buckle joint

Now,

$Pd = \Pi/4. dc^{2}. ft$

$2600 = \Pi/4. dc^{2}. 70$ 01

$dc = 6.87$ mm

Rod diameter $d = 6.87 /0.84$ 01

$= 8.77$ mm ≈ 9 mm

2. Attempt any FOUR. 16

a) What factors are to be considered while selection of the materials for design of machine element? 04

Answer: ***(Any Four – 1 Marks Each)***

The following factors are to be considered while selection of the materials for design of machine element:

1. **Availability:** The material should be readily available in the market, in large enough quantities to meet the requirements. Cast iron & aluminum alloys are easily available in market.
2. **Material Cost:** For every application there is a limiting cost beyond which designer can't afford. When this limit exceeded, the designer consider other alternative material.
3. **Mechanical properties:** It is a technical factor governing the selection of material. They include strength under fluctuating, static load, elasticity, stiffness, toughness, hardness. Depending upon the working conditions & requirements, the properties are considered and material is selected. 04
   Eg. Material for connecting rod should be capable to withstand fluctuating stress induced so here endurance limit becomes the selection criteria.
4. **Manufacturing considerations:** Machinability of material is an important considered in selection. When material is complex shaped, casting property is important. The manufacturing

processes such as forging, casting, rolling, machining, extrusion etc. governs the selection of material.

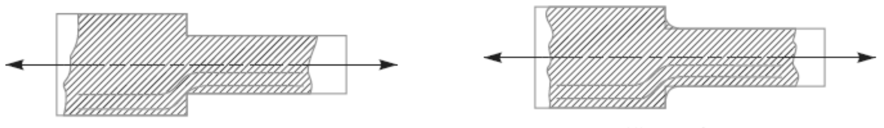
5. **Manufacturing Cost:** It includes cost of processing the material into finished goods.

b) Mention the methods of reducing stress concentration with suitable examples. 04

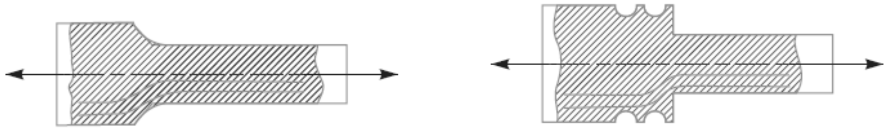
Answer: ***(Listing – 2 marks & explanation/example of any One – 2 Marks Each)***

The methods of reducing stress concentration:

1. **The methods of reducing stress concentration in cylindrical members subjected to tensile load.**



(*a*) Poor (*b*) Good

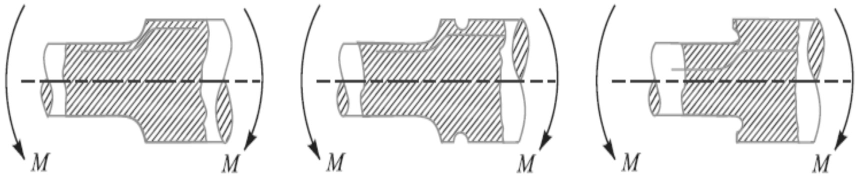


(*c*) Preferred (*d*) Preferred

In Fig. (a) it is seen that stress lines tend to bunch up and cut very close to the sharp re-entrant corner. In order to improve the situation, fillets may be provided, as shown in Fig. (b) and (c) to give more equally spaced flow lines. It may be noted that it is not practicable to use large radius fillets as in case of ball and roller bearing mountings. In such cases, notches may be cut as shown in Fig.(d)

2. **The methods of reducing stress concentration in cylindrical members with shoulders subjected to bending moment.**

04



(*a*) Poor (*b*) Good (*c*) Preferred

Figure. Methods of reducing stress concentration in cylindrical members with shoulders.

3. **The methods of reducing stress concentration in cylindrical members with shoulders hole, subjected to tensile load.**

(*a*) Poor (*b*) Preferred

Figure. Methods of reducing stress concentration in cylindrical members with holes.

4. Methods of reducing stress concentration in cylindrical members with threads.

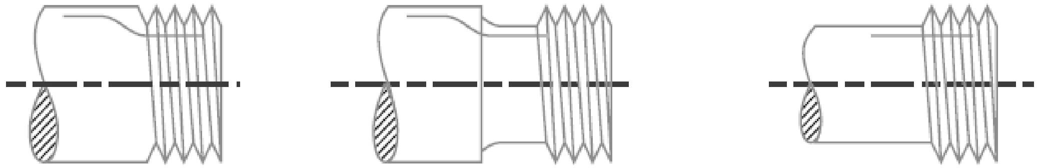

(*a*) Poor (*b*) Good (*c*) Preferred

Figure. Methods of reducing stress concentration in cylindrical members with threads.

5. Methods of reducing stress concentration of a press fit

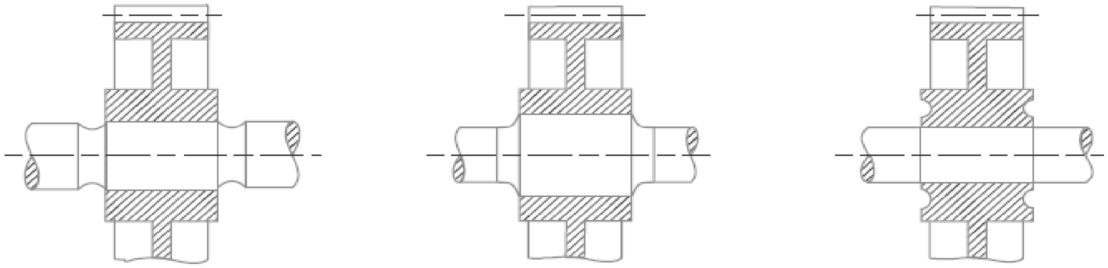

(*a*) (*b*) (*c*)

Figure. Methods of reducing stress concentration of a press fit

The stress concentration effects of a press fit may be reduced by making more gradual transition from the rigid to the more flexible shaft. The various ways of reducing stress concentration for such cases are shown in (a), (b) and (c).

c)Draw a neat and well labeled diagram of fully floating rear axle. 04

Answer: ***(Credit should be given to any equivalent sketch)***

04

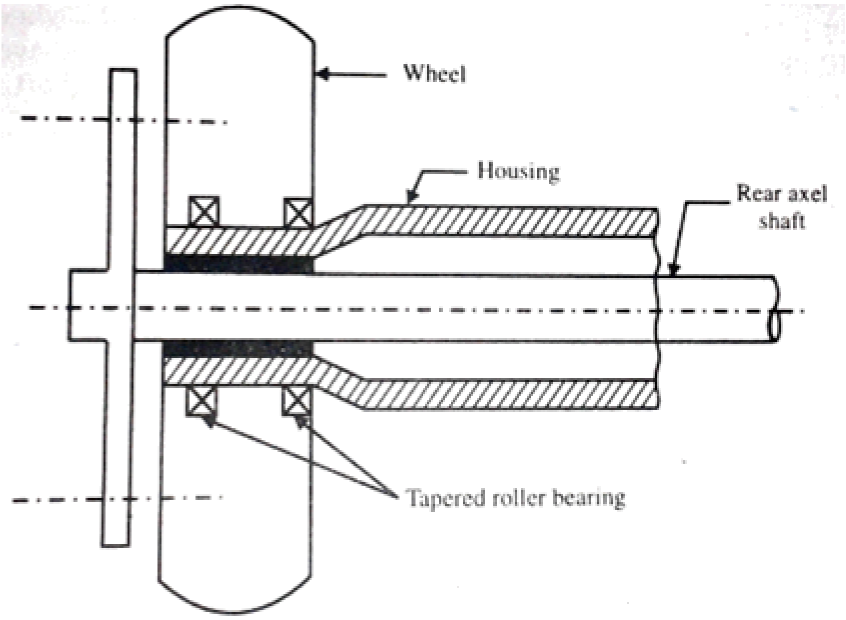


Figure. Fully floating rear axle

d) Draw a stress strain diagram for ductile material and state its importance. 04

Answer:

Stress-Strain diagram for ductile material:

03

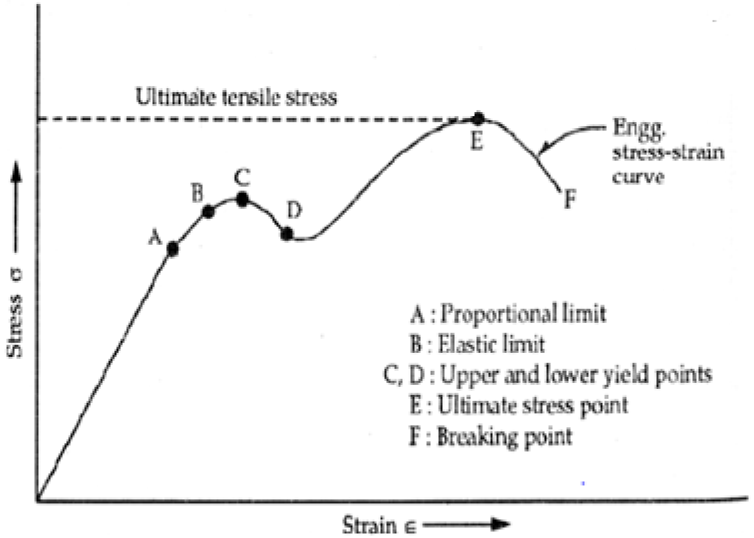


Figure. Stress-Strain diagram for ductile material

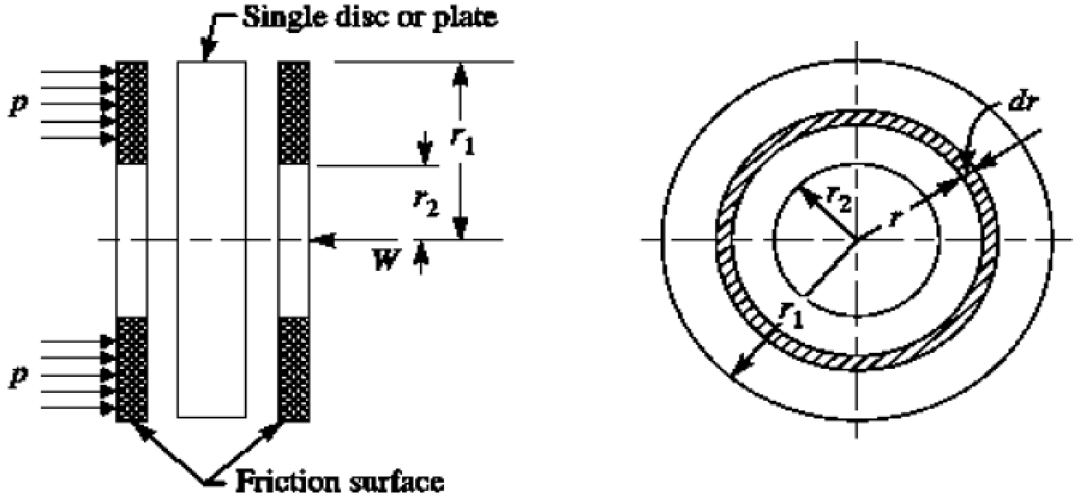
Importance of Stress-Strain diagram for ductile material:

The most important properties of materials are strength, elasticity, stiffness, ductility etc. From stress-strain diagram, material properties like ultimate strength, elastic limit, ductility etc. can be found out. Hence, these values can be used for designing and selection of proper material for machine design. 01

e)Write the design procedure for single plate clutch according to uniform pressure theory. 04

Answer:

Consider two friction surfaces maintained in contact by an axial thrust (*W)* as shown in Fig. 01



Let,

T = Torque transmitted by the clutch,
p = Intensity of axial pressure with which the contact surface are held together,
r_1 and r_2 = External and internal radii of friction faces,
r = Mean radius of the friction face, and
μ = Coefficient of friction.

Consider an elementary ring of radius r and thickness dr as shown in Fig.

We know that area of the contact surface or friction surface = $2\pi.\ r.dr$

Therefore Normal or axial force on the ring,

$$\delta W = \text{Pressure} \times \text{Area} = p \times 2\pi.\ r.dr$$

and the frictional force on the ring acting tangentially at radius r,

$$Fr = \mu \times \delta W = \mu.p \times 2\pi.\ r.dr$$

Therefore Frictional torque acting on the ring,

$$Tr = Fr \times r = \mu p \times 2\pi\ r.dr \times r = 2\ \pi\mu p.\ r^2.dr$$ 01

Considering uniform pressure:

When the pressure is uniformly distributed over the entire area of the friction face as shown in Fig. , then the intensity of pressure,

$$p = \frac{W}{\pi\left[(r_1)^2 - (r_2)^2\right]}$$

Where,

W = Axial thrust with which the friction surfaces are held together.

We have discussed above that the frictional torque on the elementary ring of radius r and thickness dr is

$$T_r = 2\pi\ \mu.p.r^2.dr$$

Integrating this equation within the limits from r_2 to r_1 for the total friction torque.

Total frictional torque acting on the friction surface or on the clutch,

$$T = \int_{r_2}^{r_1} 2\pi\ \mu.p.r^2.dr = 2\pi\mu.p\left[\frac{r^3}{3}\right]_{r_2}^{r_1}$$

$$= 2\pi\ \mu.p\left[\frac{(r_1)^3 - (r_2)^3}{3}\right] = 2\pi\ \mu \times \frac{W}{\pi\ [(r_1)^2 - (r_2)^2]}\left[\frac{(r_1)^3 - (r_2)^3}{3}\right]$$

... (Substituting the value of p) 02

$$= \frac{2}{3}\mu.\ W\left[\frac{(r_1)^3 - (r_2)^3}{(r_1)^2 - (r_2)^2}\right] = \mu\ .W.R$$

where $R = \frac{2}{3}\left[\frac{(r_1)^3 - (r_2)^3}{(r_1)^2 - (r_2)^2}\right]$ = Mean radius of the friction surface.

3. Attempt any FOUR: 16

a) What are the advantages of standardization? 04

Answer: ***(Any four – 1 marks each)***

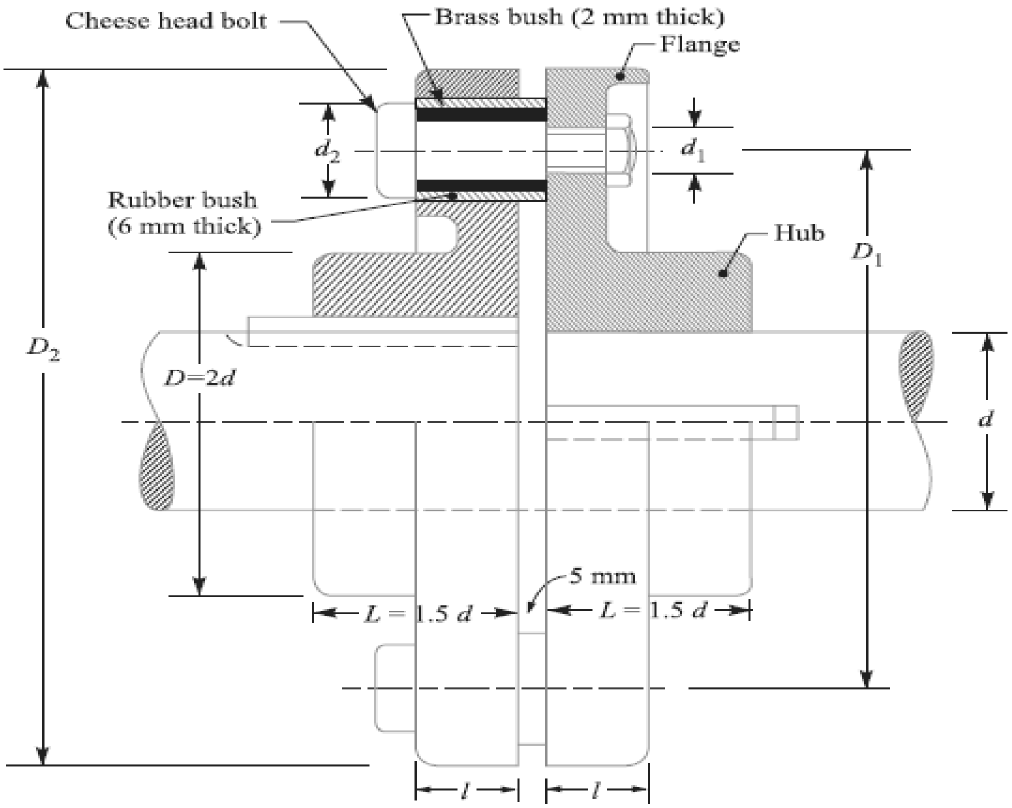
Advantages of standardization:

1. Interchangeability of product or element is possible.
2. Mass production is easy.
3. Rate of production increases.
4. Reduction in labour cost.
5. Limits the variety of size and shape of product.
6. Overall reduction in cost of production.
7. Improves overall performance, quality and efficiency of product.
8. Better utilization of labour, machine and time

04

b) Draw a neat well labeled diagram of bushed pin flexible coupling. 04

Answer:



04

Figure. Bushed Pin Flexible Coupling

Where,

d = diameter of shaft , d_1 = diameter of pin at neck, d_2 = diameter of pin at the rubber bush,
D = diameter of hub,
D_1 = diameter of pitch circle of pins,
D_2 = diameter of flange
l = length of hub

c) Determine length, width and thickness of a mild steel rectangular sunk key required for 80mm diameter shaft of mild steel to resist a torque of 5000 N-m.
Take –fs = 50 N/mm^2 , fc = 120 N/mm^2 04

Answer:

Given:

fs = 50 N/mm^2, fc = 120 N/mm^2,
d = 80 mm, T = 5000 N-m = 5000 X 10^3 N-mm

Let,
l = length of key, W = width of the key, t = thickness of key,
P = tangential force acting at circumference of the shaft

P = T / (d/2)
= (5000 x 10^3) / (80/2) 01
P = 1.25 x 10^5 N

Assuming l = 1.5 d
l = 1.5 x 80 01
l = 120 mm

Considering shearing of key,
P = l x b x fs
1.25 x 10^5 = 120 x b x 50 01
b = 20.86 mm

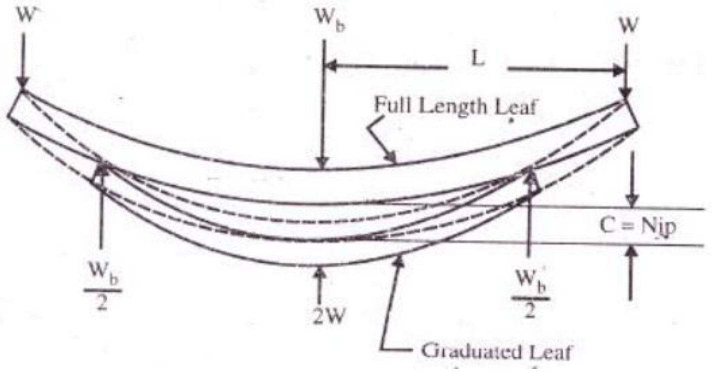
taking next higher value, b = 21 mm.

Considering crushing of key,
P = l x (t/2) x fc
1.25 x 10^5 = 120 x (t/2) x 120
t = 17.36 01

taking next higher value, t = 17.5 mm

d) Why nipping is provided in leaf spring? 04

Answer: ***(Sketch – 2 marks & explanation – 2 marks)***



02

Figure. Nipping

When the central bolt holding the leaves is tightened, the full length leaf bend back as shown by dotted line. And will have an initial stress in opposite direction. The graduated leaves will have an initial stress in the same direction as that of normal load. When the load is applied, the full length leaf gets relieved first; consequently the full length leaf will be stressed less than graduated leaf. The initial leaf between leaves may be so adjusted that under maximum load conditions, all the leaves are equally stressed. So for this reason nipping is provided in leaf spring.	02
e) What is the effect of key way cut into the shaft?	04
Answer: **Effect of key way cut into the shaft:** The keyway cut into the shaft reduces the load carrying capacity of the shaft. This is due to the stress concentration near the corners of the keyway and reduction in the cross-sectional area of the shaft. It other words, the torsional strength of the shaft is reduced. The following relation for the weakening effect of the keyway is based on the experimental results by H.F. Moore. $$e = 1- 0.2 (w/d) – 1.1 (h/d)$$ where, e = Shaft strength factor, w = width of key way, d = diameter of shaft, and h = depth of keyway It is usually assumed that the strength of the keyed shaft is 75% of the solid shaft. In case the keyway is too long and the key is of sliding type, then the angle of twist is increased in the ratio K_θ as given by the following relation : $$k_\theta = 1 + 0.4\left(\frac{w}{d}\right) + 0.7\left(\frac{h}{d}\right)$$ Where, k_θ = Reduction factor for angular twist.	04
4. A) Attempt any THREE:	12
a)What points are taken into consideration for design of the piston (any eight points)?	04
Answer: ***(Any Eight – ½ Marks Each)*** **Following are the points are taken into consideration for design of the piston: (any eight)** 1. It should have enormous strength to withstand the high gas pressure and inertia forces. 2. It should have minimum weight to minimize the inertia forces. 3. It should have good and quick dissipation of heat from crown to the rings and bearing area and then to the cylinder walls. 4. It should form an effective gas and oil sealing of the cylinder. 5. It should have sufficient rigid construction to withstand thermal and mechanical distortion. 6. It should provide sufficient bearing area to prevent undue wear. 7. It should have symmetrical design for even expansion under thermal loads, as free as possible from discontinuities. 8. It should have high speed reciprocation without noise. 9. It should have minimum work of friction. 10. It should have a little of no tendency towards corrosion or picking up.	04

b) State types of leaves used in engineering practice with their application. 04

Answer:

Types of leaves: 02

1. Full length leave
   a. Full length leave with eye,
   b. Full length leave without eye**.**
2. Graduated leave

Applications of leaves:-

1. It is used in semielliptical leaf spring,
2. It is used in quarter elliptical leaf spring, 02
3. It is used in three quarter elliptical leaf spring,
4. It is used in full elliptical leaf spring.

c)What materials are used for clutch lining friction surfaces? 04

Answer: ***(Any Four – 1 Marks Each)***

Materials are used for clutch lining friction surfaces: (any four)

1. Cast iron on cast iron or steel
2. Hardened steel on Hardened steel
3. Bronze on cast iron or steel
4. Pressed asbestos on cast iron or steel 04
5. Powder metal on cast iron or steel

d) Explain aesthetic consideration in designing automobile components. 04

Answer***: (Any two – 2 marks each)***

Aesthetic consideration in designing automobile components: 04

1. **Shape:** The external appearance is an important feature, which gives grace & luster to the product. This is true for automobile, household appliances. The role of designer is to create the new shapes of machines which have aesthetic look.

   E.g. Aerodynamic shape of aero plane for functional requirements to resist minimum air resistance.

2. **Colour:** Selection of proper colour is an impotent consideration in product design. Many colors are associated with different conditions.

   Morgan has suggested the meaning of colors in the following table.

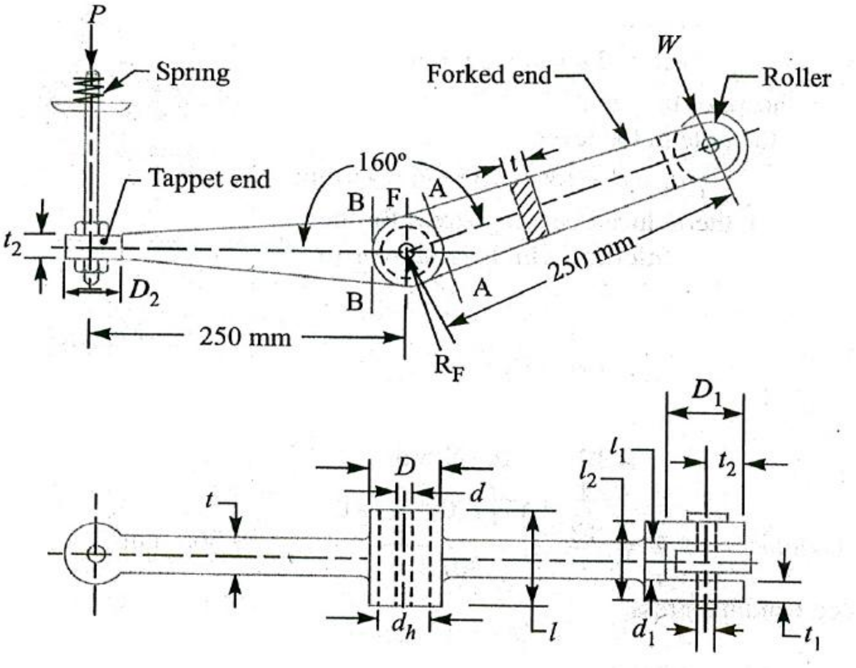
Colour	**Meaning**
Red	Danger-Hazard- Hot
Orange	Possible danger
Yellow	Caution
Green	Safety
Blue	Caution-Cold
Grey	Dull Product

3. **Surface finish:** For greater strength, bearing loads, good fatigue life & wear qualities of product, and the good surface finish is required. Better surface finish always attracts the observers.

B) Attempt any ONE :	06
a) Explain the diagram procedure of a Rocker arm for operating exhaust valve.	06

Answer: ***(Sketch – 3 marks & Explanation – 3 marks)***

Diagram procedure of a Rocker arm for operating exhaust valve:



03

Figure. Rocker arm for operating exhaust valve

In designing a rocker arm the following procedure may be followed :

1. Rocker arm is usually I-Section it is subjected to bending moment. To find bending moment it is assumed that the arm of the lever extends from point of application of load to centre of pivot.
2. The ratio of length to the diameter of the fulcrum pin and roller pin is taken as 1.25. The permissible bearing pressure on this pin is taken from 3.5 to 6 N/mm2.
3. The outside diameter of boss at fulcrum is usually taken twice the diameter of the pin at fulcrum. The boss is provided with a 3mm thick phosphor bronze bush to take up the wear.
4. One end of rocker arm has a forked end to receive roller.
5. The outside diameter of the eye at the forked end is also taken as twice the diameter of pin. The diameter of roller is slightly larger (at least 3mm more) than the diameter of eye at the forked end. The radial thickness of each eye of the forked end is taken half the diameter of pin. Some clearance about 1.5mm must be provided between the roller and the eye at the forked end so that roller can move freely. The pin should, therefore be checked for bending.
6. The other end of rocker arm (i.e. tappet end) is made circular to receive the tappet which is a stud with a lock nut. The outside diameter of the circular arm is taken as twice the diameter of the stud. The depth of section is also taken twice the diameter of stud.

03

b) Design a big end bolts of connecting rod with following data 06
Maximum inertia force on the connecting rod 3000 N, at 4500 rpm.
Allowable stress for bolt = 65 N/mm^2

Answer:
Given:

fi = 3000 N,
ft = 65 N/mm^2.

The bolts are under tension due to load,

$$f_i = \frac{\pi}{4} d_c^2 \times f_t \times 2$$

$$3000 = \frac{\pi}{4} (d_c)^2 \times 65 \times 2$$

$$d_c = 5.4$$ 03

$$\text{Now diameter of bolt} = \frac{d_c}{0.84}$$

$$d = 6.45\,\text{mm}$$

$$d = 7\text{ mm} \text{ ...Say}$$ 03

5. Attempt any TWO : 16

a) A truck spring has 12 numbers of leaves two of which are full length leaves. The spring supports are 1.05m apart and central band is 85 mm wide. The central load is to be 5.4 kN with a permissible stress of 280 N/mm^2. Determine the thickness and width of the steel spring leaves. The ratio of the total depth of the width of spring is 3. Also determine the deflection of the spring . 08

Answer :

Given : $n = 12$, $n_F = 2$, $2L_1 = 1.05\text{m} = 1050\text{mm}$, $l = 85\text{mm}$, $2W = 5.4\,\text{kN} = 5400\text{N}$
or $W = 2700$ N, $f_F = 280$ N/mm^2.

Thickness and width of the spring leaves

Let , t = Thickness of the leaves,
and b = Width of the leaves

Since it is given that the ratio of the total depth of the spring $(n \times t)$ width of the spring (b) is 3 , therefore

$$\frac{n \times t}{b} = 3$$

$$\frac{12 \times t}{b} = 3$$ 01

or $b = 12\,t/3 = 4t$

We know that the effective lenght of the spring,

$$2L = 2L_1 - l = 1050 - 85 = 965\text{mm}$$

$$L = \frac{965}{2} = 482.5\text{ mm}$$ 01

and number of graduated leaves ,

$$n_G = n - n_F = 12 - 2 = 10$$ 01

Assuming that the leave are not initially stressed therefore maximum stress or bending stress for full length leaves (f_F)

$$280 = \frac{18\,W.L}{b.t^2(2n_g + 3n_F)} = \frac{18\times 2700\times 482.5}{4\,t\times t^2(2\times 10+3\times 2)} = \frac{225.476}{t^3}$$ 01

$$t^3 = 225.476/280 = 805.3$$

or $t = 9.3 \text{ say } 10\text{ mm}$ 01

and $b = 4\,t = 4\times 10 = 40\text{mm}$ 01

Deflection of the spring :

We know that deflection the spring

$$\delta = \frac{12\,W.L^3}{E.b.t^3(2n_g + 3n_F)} = \frac{12\times 2700\times (482.5)^3}{0.21\times 10^6\times 40\times 10(2\times 10+3\times 2)}\text{ mm}$$

$$= 16.7\text{ mm} \;\ldots\ldots\ldots\ldots\ldots.. \;(\text{Taking } E = 0.21\times 10^6\text{ N/mm}^2)$$ 02

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b) Draw a neat sketch of cotter joint. The joint has to withstand a load 60 kN find 08

i) The diameter of rod

ii) Width of cotter

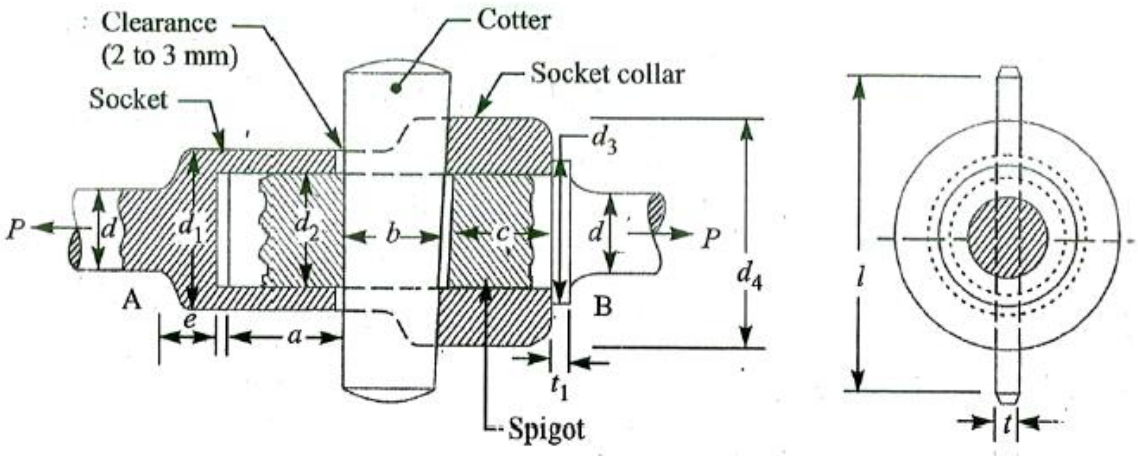
Permissible stresses are = ft = 70 N/mm^2, fs= 60 N/mm^2, fb= 45N/mm^2, fc= 2 ft.

Answer***: (Sketch – 3 marks & dia. Of rod – 2 marks & width of cotter – 3 marks)***

Let,

P = load carried by the rods
d = Diameter of the rods
d1 = outside diameter of socket
d2= Diameter of Spigot or inside diameter of socket
d3= outside diameter of spigot collar
t1= thickness of spigot collar
d4 = diameter of socket collar
c = thickness of socket collar
b = mean width of cotter
t = thickness of cotter

l = length of cotter
a = distance from end of the slot to the end of rod



03

Figure. Cotter Joint

Given,

$P=60$ kN$=60\text{x}10^3$ N
$ft = 70$ N/mm^2
$fb = 45$ N/mm^2
$fs = 70$ N/mm^2
$fc = 2\ ft = 140$ N/mm^2

Let,

1. Diameter of rods ‘d’,

Considering the failure of rod in tension,

$$\text{Load, } P = (\pi / 4) \text{ x } d^2 \text{ x } ft$$

$$60 \text{ x}10^3 = (\pi / 4) \text{ x } d^2 \text{ x } 70$$

$$d = 33.03 \text{ mm}$$ 02

$$d = 34 \text{ mm} \ldots \text{ say}$$

2. Diameter of spigot

$$P = [((\pi / 4) \text{ x } d_2^2) – (d_2 \text{ x } t)].\ ft$$

Assume, $t = (d_2 /4)$

$$P = [((\pi / 4) \text{ x } d_2^2) – (d_2^2/4)].\ ft$$

$60000 = [((\pi / 4) \times d_2^2) - (d_2^2/4)].\ 70$

$d_2 = 40$ mm

$\therefore\ t = (d_2 /4) = 10$ mm

3. Checking spigot rod for crushing stress:

$P = d_2 \times t \times fc$

$fc = 150$ N/mm^2

Permissible fc is greater than induced crushing stress so design is unsafe.

For safety design , redesign the value of d_2

$P = d_2 \times t \times fc$

$60000 = (d_2^{\ 2} / 4) \times 140$

$d_2 = 41.4$ mm

$\therefore\ d_2 = 42$ mm … say

$t = (d_2 /4) = 10.5$ mm

4. Design width of cotter

$P = 2b \times t \times fs$

$60000 = 2 \times b \times 10.5 \times 60$

$b = 47.62$ mm

$\therefore\ b = 48$ mm… say

03

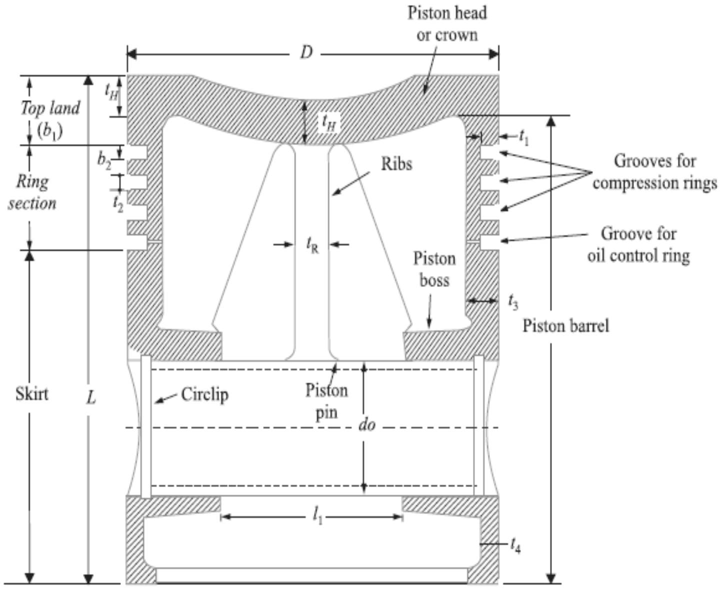
c) Design the skirt length of the piston. With the given data of petrol engine. Maximum pressure inside the cylinder =4.5 N/mm^2. Piston diameter =70mm, side thrust is limited to 8% of maximum load on the piston. Allowable bearing pressure = 0.3 N/mm^2, also draw a neat sketch of piston.	08
Answer: Given, $P_{max} = 4.5 N/mm^2$ $\text{Piston dia. } D = 70mm$ $\text{side thrust} = 8\% = \frac{8}{100} = 0.08$ $P_b = 0.3 N/mm^2$ Let, R = Normal side thrust acting on piston skirts F = Total force produced due to combustion P_{max} = max. gas pressure inside the engine D = Dia. Of piston $F = P_{max} \times \frac{\pi}{4} D^2$ $F = 4.5 \times \frac{\pi}{4} (70)^2 = 17.318 \times 10^3 N$ $R = 0.08 \times F = 0.08 \times 17.318 \times 10^3 \qquad \because \text{side thrust} = 8\%$ $\therefore \quad R = 1385.44 N$ Let, $l_1 = \text{length of piston skirt}$ The piston skirt act as a bearing inside the liner We have , $R = l_1 \times D \times P_b$ Where $P_b =$ allowable bearing pressure on the piston skirt	01 01 01

$$\therefore\ l_1 = \frac{1385.44}{70 \times 0.3}$$

$$l_1 = 65.97\ \text{mm}$$

01

$$\therefore\ l_1 = 66\ \text{mm}$$

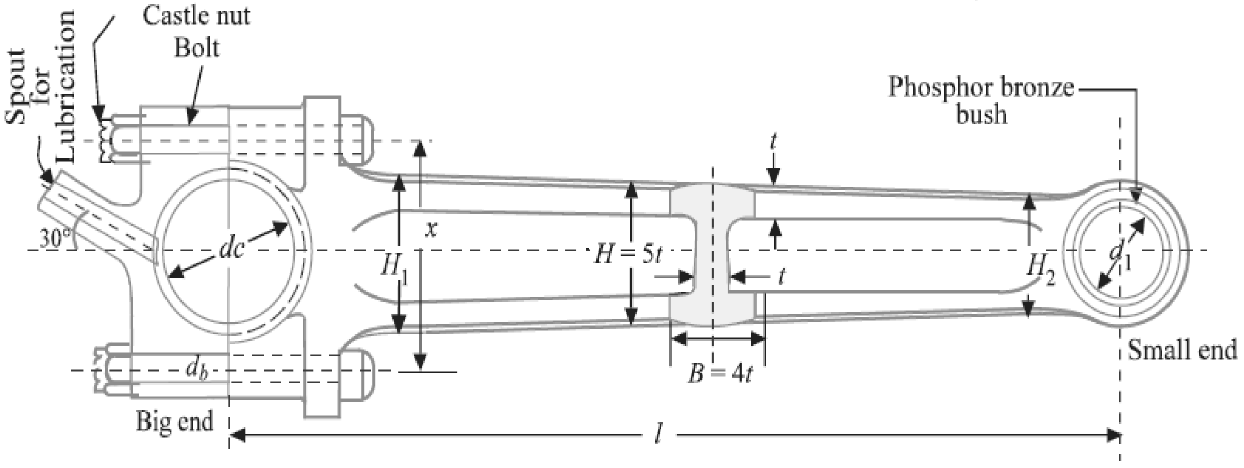


04

Figure. Piston

6. Attempt any TWO:	16
a) Draw a neat proportionate sketch of connecting rod. Why I- section is used as cross section of it? What material is selected for connecting rod?	08

Answer:



04

Figure. Connecting Rod

Why I- section is used as cross section of connecting rod?

I-sections are usually found to be most suitable for high speed engine connecting rod lightness is essential in order to keep inertia forces as small as possible .I-section also provides sufficient strength required to with stand momentary high gas pressure in the cylinder .I- section is four times stronger for buckling about X-X axis than Y-Y axis. Thus I-section fulfills most desirable conditions for connecting rod i.e. adequate strength and stiffness and minimum weight. 03

Material for connecting rod: Medium carbon steel or alloy steel. 01

b) A four stroke diesel engine has the following specifications : 08

Brake power = 5 kW, Speed 1200 rpm, indicated mean effective pressure = 0.35 N/mm^2,
Mechanical efficiency = 80%
Determine:
i) Bore and length of the cylinder
ii) Thickness of the cylinder head

Answer: ***(Note: Assume l = 1.5 D OR l = 1.08 D)***

Given:

B.P. = 5kW = 5000 W ;
N = 1200 r.p.m. or n = N / 2 = 600 ;
$p_m = 0.35$ N/mm^2;
$\eta_m = 80\% = 0.8$

1. *Bore and length of cylinder*

Let D = Bore of the cylinder in mm,
A = Cross-sectional area of the cylinder = $\frac{\pi}{4} \times D^2$ mm^2
l = Length of the stroke in m.
= 1.5 D mm = 1.5 D / 1000 m ....(Assume)

We know that the indicated power,

$$I.P = B.P. / \eta_m = 5000 / 0.8 = 6250 \text{ W}$$ 02

We also know that the indicated power ($I.P.$),

$$6250 = \frac{p_m . l . A . n}{60} = \frac{0.35 \times 1.5D \times \pi D^2 \times 600}{60 \times 1000 \times 4} = 4.12 \times 10^{-3} D^3$$

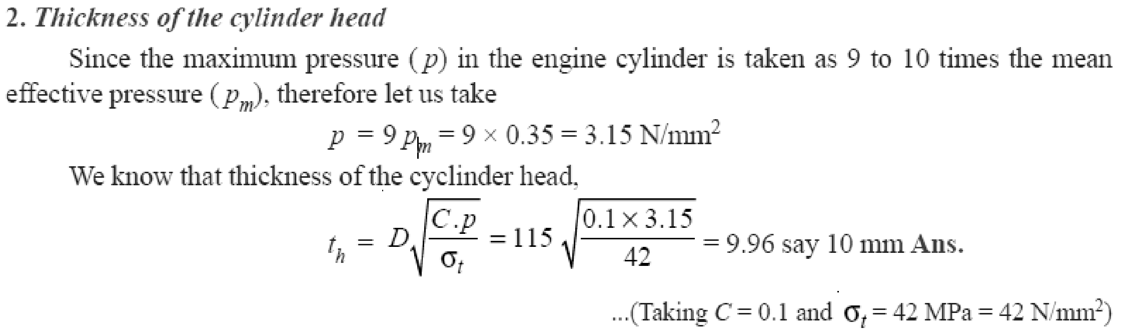
...($\because$ For four stroke engine, $n = N/2$)

$\therefore$ $D^3 = 6250 / 4.12 \times 10^{-3} = 1517 \times 10^3$ or D = 115 mm **Ans.**

and $l = 1.5\, D = 1.5 \times 115 = 172.5$ mm 02

Taking a clearance on both sides of the cylinder equal to 15% of the stroke, therefore length of the cylinder,

$$L = 1.15\, l = 1.15 \times 172.5 = 198 \text{ say } 200 \text{ mm}$$ **Ans.** 02



2. *Thickness of the cylinder head*

Since the maximum pressure (p) in the engine cylinder is taken as 9 to 10 times the mean effective pressure (p_m), therefore let us take

$$p = 9\,p_m = 9 \times 0.35 = 3.15 \text{ N/mm}^2$$

We know that thickness of the cyclinder head,

$$t_h = D\sqrt{\frac{C.p}{\sigma_t}} = 115\sqrt{\frac{0.1 \times 3.15}{42}} = 9.96 \text{ say } 10 \text{ mm } \textbf{Ans.}$$

...(Taking $C = 0.1$ and $\sigma_t = 42$ MPa $= 42$ N/mm^2)

02

c) A four speed gear box is to be constructed for providing the ratio 1.0, 1.46, 2.28 and 3.93 to 1 as nearly as possible. The diametral pitch of gear is 3.25 mm and the smallest pinion is to have at least 15 teeth.
Determine the suitable number of teeth of the different gear. Also calculate the distance between main and layout shaft. 08

Answer: ***(Assume module of 3.25mm instead of diametral pitch)***

$$G_1 = \frac{T_B}{T_A} \times \frac{T_D}{T_C} = 3.93$$

We have $$\frac{T_B}{T_A} \times \frac{T_D}{T_C} = \sqrt{3.93} = 1.98$$

Adopting $$T_A = T_C = 15 \text{ the lowest value given}$$

We get $$T_B = T_D = 1.98 \times 15 = 29.7 = 30$$ 01

Thus actual ratio $$= \frac{30}{15} \times \frac{30}{15} = 4:1$$

$$T_A + T_B = T_C + T_D = T_E + T_F = T_G + T_H = 45$$ 01

Second gear ratio

$$G_2 = \frac{T_B}{T_A} \times \frac{T_F}{T_E} = 2.28$$

Or $$\frac{T_F}{T_E} = 2.28 \times \frac{T_A}{T_B} = 2.28 \times \frac{15}{30} = 1.14$$

Hence, $$T_E + T_F = 2.14 \times T_E = 45$$ 01

Or $$T_E = \frac{45}{2.14} = 21$$

and $T_F = 45 - 21 = 24$	01
The actual ratio $= \frac{30}{15} \times \frac{24}{21} = 2.286:1$	
Third gear ratio,	
$G_3 = \frac{T_B}{T_A} \times \frac{T_H}{T_G} = 1.46$	
Or $\frac{T_H}{T_G} = \frac{1.46}{2} = 0.73$	01
But $T_H + T_G = 45$	
Or $T_G = \frac{45}{1.73} = 26$	01
Hence, $T_H = 45 - 26 = 19$	
Actual ratio $= \frac{30}{15} \times \frac{19}{26} = 1.461 : 1$	
Top gear ratio $G_4 = 1:1$	
The centre distance between the shaft	
$= \frac{3.25 \times 45}{2}$	02
$= 73.125\,\text{mm}$	