MACHINE COMPONENT DESIGN (ME-504)

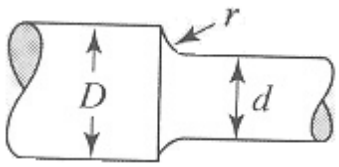
TUTORIAL UNIT-1

Q1. Find the maximum stress developed in a stepped shaft subjected to a twisting moment of 100 Nm as shown in figure**.** What would be the maximum stress developed if a bending moment of 150 Nm is applied?

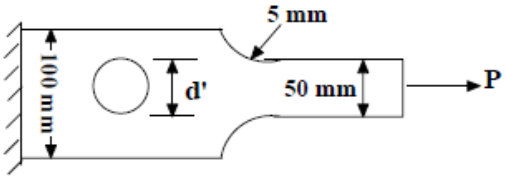
r = 6 mm

d = 30 mm

D = 40 mm.

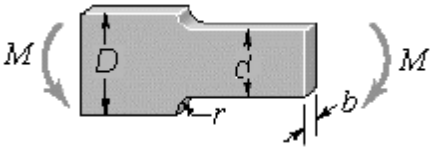


Q2. In the plate shown in figure it is required that the stress concentration at Hole does not exceed that at the fillet. Determine the diameter of hole.



Q3.A rectangular stepped steel bar is shown in figure. The bar is loaded in bending. Determine the fatigue stress-concentration factor if ultimate stress of the materials is 689 MPa.

r = 5mm
D = 50 mm
d = 40 mm
b = 1 mm



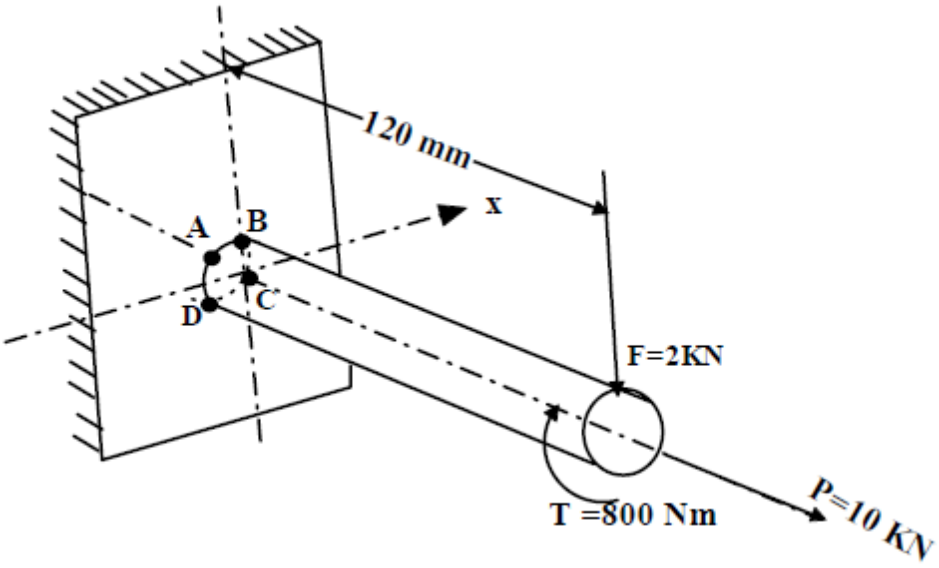
Q4. A shaft is loaded by a torque of 5 KN-m. The material has a yield point of 350 MPa. Find the required diameter using (Take a factor of safety of 2.5.)

(a) Maximum shear stress theory

(b) Maximum distortion energy theory

Q5. A rotating bar made of steel 45C8 ($S_{ut} = 630\ N/mm^2$) is subjected to a completely reversed bending stress. The corrected endurance limit of the bar is $315 N/mm^2$. Calculate the fatigue strength of the bar for a life of 90,000 cycles.

Q6. A cantilever rod is loaded as shown in the figure. If the tensile yield strength of the material is 300MPa determine the rod diameter using (a) Maximum principal stress theory (b) Maximum shear stress theory (c) Maximum distortion energy theory.



Q7. What are the methods of reducing stress concentration? Explain repeated stress.

Q8. What is S-N curve? Explain high and low cycle fatigue.

Q9. Explain the modified Goodman diagram for bending and torsional shear stresses.

Q10. What is the difference between the Gerber curve and Soderberg and Goodman lines?

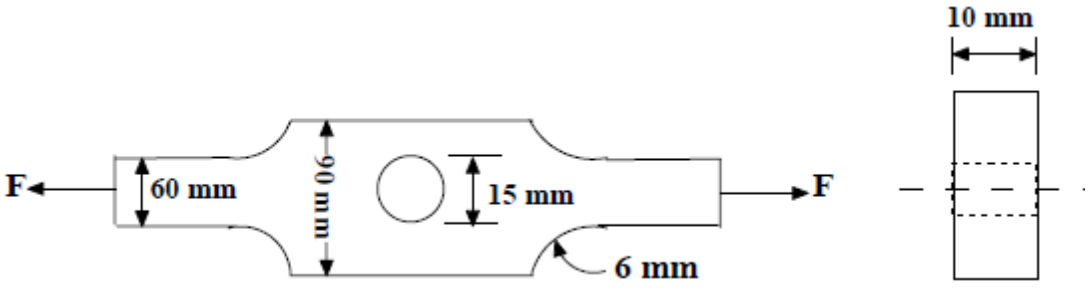
Q11. A hot rolled steel shaft is subjected to a torsion load that varies from 300Nm clockwise to100Nm anticlockwise as an applied bending moment at a critical section varies from+400Nm to -200Nm. The shaft is of uniform cross-section and no keyway is present at the critical section. Determine the required shaft diameter by taking FS=1.5 for the material, take$S_{ut} = 560Mpa;\ S_{yt} = 420Mpa$.

Q12. A cold drawn steel rod of circular cross-section is subjected to variable bending moment of 500Nm as the axial load varies from 4.50KN to 13.50KN. The maximum bending moment occurs at the same instant that the axial load is maximum. Find the diameter of rod neglecting stress concentration.

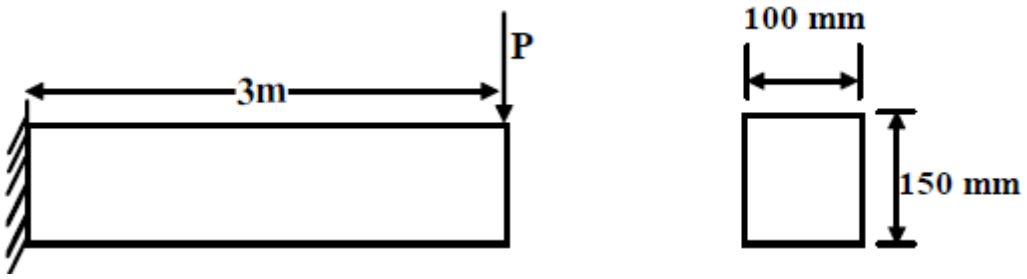
Take FS=2, $S_{ut} = 560\ MN/m^2$; $S_{yt} = 476\ MN/m^2$

MACHINE COMPONENT DESIGN (ME-504)
ASSIGNMENT UNIT-1

Q1. A portion of a connecting link made of steel is shown in figure. The tensile axial force F fluctuates between 15 KN to 60 KN. Find the factor of safety if the ultimate tensile strength and yield strength for the material are 440 MPa and 370 MPa respectively and the component has a machine finish.



Q2.A 3m long cantilever beam of solid rectangular cross-section of 100mm width and 150mm depth is subjected to an end loading P as shown in the figure. If the allowable shear stress in the beam is 150 MPa, find the safe value of P based on shear alone.



Q3. A forged steel bar, 50 mm in diameter, is subjected to a reversed bending stress of $250N/mm^2$. The bar is made of steel 40C8 (S_{ut} =$600N/mm^2$). Calculate the life of the bar for a reliability of 90%.

Q4. The work cycle of a mechanical component subjected to completely reverse bending stresses consists of the following three elements:

(1) $\pm 350N/mm^2$ for 85% of time
(2) $\pm 400N/mm^2$ for 12% of time
(3) $\pm 500N/mm^2$ for 3% of time

The material for the component is 50C4 ($S_{ut} = 660\ N/mm^2$) and the corrected endurance limit of the component is $280N/mm^2$. Determine the life of the component.

Q5. A transmission shaft of cold drawn steel 27Mn2 ($S_{ut} = 500N/mm^2$and $S_{yt} = 300N/mm^2$) is subjected to a fluctuating torque which varies from -100 N-m to +400 N-m. the factor of safety is 2 and the expected reliability is 90%. neglect the effect of stress concentration. Determine the diameter of the shaft.

Assume the distortion energy theory of failure.

Q6. Determine the thickness of a 120 mm wide uniform plate for safe continuous operation. If the plate is to be subjected to a tensile load, that has a maximum value of 250 KN and a minimum value of 100 KN. The properties of the plate material are as follows:

Endurance limit stress= 225 MPa

Yield point stress = 300 MPa

The factor of safety based on yield point may be taken as 1.5.

Q7. A leaf spring in an automobile is subjected to cyclic stresses. The average stress = 150MPa variable stress = 150 MPa; ultimate stress = 630 MPa; yield point stress = 350 MPa and endurance limit = 150 MPa; estimate, under factor of safety the spring is working, by Goodman and Soderberg formula.

Q8. Determine the size of a piston rod subjected to a total load of having cyclic fluctuations from 15 KN compressions to 25 KN in tension. The endurance limit is 360 MPa and yield strength is 400 MPa. Take impact factor = 1.25, factor of safety = 1.5, surface finish factor=0.8 and stress concentration factor = 2.25.

Q9. Determine the thickness of a 120mm wide uniform plate for safe continuous operation if the plate is to be subjected to a tensile load that has a maximum value of 250KN and a minimum value of 100KN. The properties of the plate material are as follows;

Endurance limit stress = 225Mpa

Yield point stress = 300Mpa

The factor of safety based on yield point may be taken as 1.5.

Q10. A leaf spring in an automobile is subjected to cyclic stresses. The average stress = 150Mpa variable stress = 500Mpa; ultimate stress = 630Mpa; yield point stress = 350Mpa and endurance limit = 150Mpa; estimate, under factor of safety the spring is working, by Goodman and Soderberg formula.

Q11. Determine the size of a piston rod subjected to a total load of having cyclic fluctuations from 15KN compression to 30KN in tension. The endurance limit is 360Mpa and yield strength is 400Mpa. Take impact factor = 1.25, FS=1.5 surface finish factor = 0.88 and stress concentration factor = 2.25.

MACHINE COMPONENT DESIGN (ME-504)

TUTORIAL UNIT-II

Q1. A shaft is supported on bearings A and B, 800 mm between centers. A 20° straight tooth spur gear having 600 mm pitch diameter, is located 200 mm to the right of the left hand bearing A, and a 700 mm diameter pulley is mounted 250 mm towards the left of bearing B. The gear is driven by a pinion with a downward tangential force while a pulley drives a horizontal belt having 180° angle of wrap. The pulley also serves as a flywheel and weighs 200N. The belt tension is 3000N and the tension ratio is 3:1. Determine the maximum bending moment and the necessary shaft diameter if the allowable shear stress of the material is 40MPa.

Q2. A steel solid shaft transmitting 15KW at 200 rpm is supported on two bearings 750 mm apart and has two gears keyed to it. The pinion having 30 teeth of 5 mm module is located 100mm to the left of the right hand bearings and delivers power horizontally to the right. The gear having 100 teeth of 5 mm module is located 150 mm to the right of the left hand bearing and received power in a vertical direction from below. Using an allowable stress of 54MPa in shear, determine the diameter of the shaft.

Q3. A mild steel shaft transmits 20KW at 200 rpm. It carries a central load of 900 and is simply supported between the bearings 2.5m apart. Determine the size of the shaft, if the allowable shear stress is 42MPa and the maximum tensile or compressive stress is not to exceed 56MPa. What size of the shaft will be required, if it is subjected to gradually applied loads.

Q4. A hollow shaft is subjected to a maximum torque of 1.5KN-m and a maximum bending moment of 3KN-m. it is subjected at the same time to an axial load of 10KN. Assume that the load is applied gradually and the ratio of the inner diameter to the outer diameter is 0.5. if the outer diameter of the shaft is 80 mm find the shear stress induced in the shaft.

Q5. A hollow steel shaft is to transmit 20KW at 300 rpm. The loading is such that the maximum bending moment is 1000N-m, the maximum torsion moment is 500N-m and axial compressive load is 15KN. The shaft is supported on rigid bearing 1.5m apart. The maximum permissible shear stress on the shaft is 40MPa. The inside diameter is 0.8 times the outside diameter. The load is cyclic in nature and applied with shock. The values for the shock factor are K_t=1.5 and K_m=1.6.

Q6. Compare the weight, strength and stiffness of a hollow shaft of the same external diameter as that of solid shaft. The inside diameter of the hollow shaft is being half the external diameter. Both the shaft has the same material and length.

MACHINE COMPONENT DESIGN (ME-504)
ASSIGNMENT UNIT-II

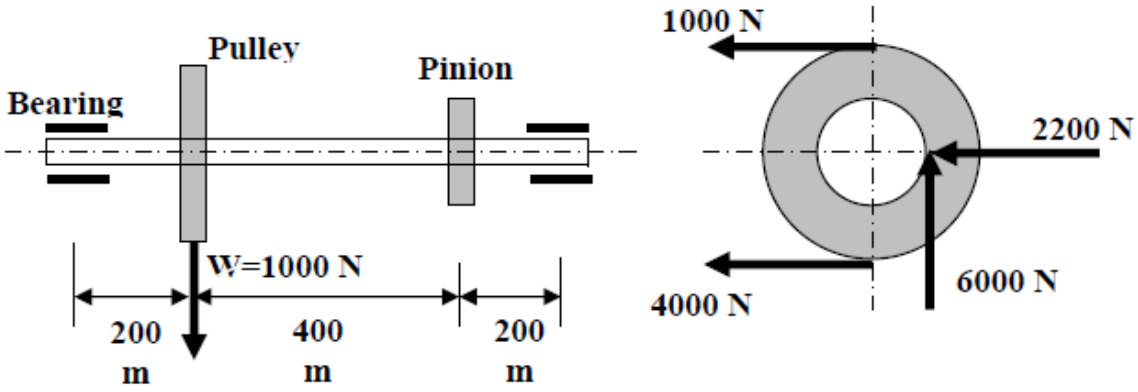
Q1. A shaft running at 400rpm transmits 10KW. Assuming allowable shear stress in the shaft as 40MPa, find the diameter of the shaft.

Q2. A hollow shaft for a rotary compressor is to be designed to transmit a maximum torque of 4750N-m. The shear stress in the shaft is limited to 50MPa. Determine the inside and outside diameter of the shaft, if the ratio of the inside to the outside diameter is 0.4.

Q3. A cylindrical shaft made of steel of yield strength 700MPa is subjected to static loads consisting of a bending moment of 10KN-m and a torsional moment of 30KN-m. Determine the diameter of the shaft using two different theories of failure and assuming a factor of safety of 2.

Q4. A line shaft rotating at 200rpm is to transmit 20KW. The allowable shear stress for the material of the shaft is 42MPa. If the shaft carries a central load of 900N and is simply supported between bearing 3meter apart, determine the diameter of the shaft. The maximum tensile or compressive strength is not to exceed 56MPa.

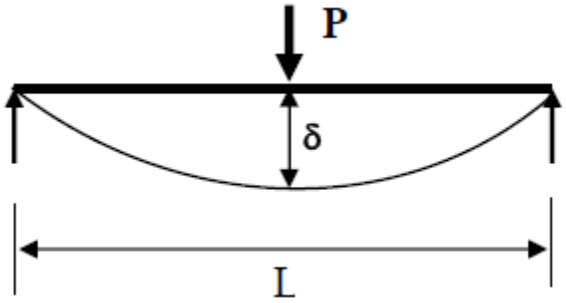
Q5. The problem is shown in the given figure. A pulley drive is transmitting power to a pinion, which in turn is transmitting power to some other machine element. Pulley and pinion diameters are 400mm and 200mm respectively. Shaft has to be designed for minor to heavy shock.



Q6. A shaft subjected to a torque of 4KN-m carries a bending moment of 1.5KN-m in vertical plane and 2KN-m in horizontal plane at a section. Determine its diameter and check for factor of safety. The determination of property in tension of the material of steel is quite reliable. The calculation of bending moment and torque is accurate. The shaft will be ground finished and heat treated to ultimate tensile strength of 700MPa with uniform micro structure.

Q7. A section of a shaft is subjected to a bending moment of 1.5KN-m and a torque of 0.5KN-m. It is proposed to check the design of shaft for three different steels having ultimate tensile strengths of 400, 700 and 1000MPa. Find the diameter of the shaft at this section for each steel and check for factor of safety of 2, assuming that a key slot of end milled type exists at the section.

Q8. Design a solid shaft of length 1m, carrying a load of 5 KN at the center and is simply supported as shown in figure. The maximum shaft deflection is 1mm. E=200GPa.



Q9. Two 400mm diameter pulleys are keyed to a simply supported shaft 500mm apart. Each pulley is 100mm from its support and has horizontal belts, tension ratio being 2.5. if the shear stress is to be limited to 80MPa while transmitting 45KW at 900rpm, find the shaft diameter if it is to be used for the input-output belts being on the same or opposite sides.

Q10. A machine shaft supported on bearings having their centers 750mm apart, transmitted 185KW at 600rpm. A gear of 200mm and 20° tooth profile is located 250mm to the right of left hand bearing and a 450mm diameter pulley is mounted at 200mm to right of right hand bearing. The gear is driven by a pinion with a downward tangential force while the pulley drives a horizontal belt having 180° angle of contact. The pulley weighs 1000N and tension ratio is 3. Find the diameter of the shaft, if the allowable shear stress of the material is 63MPa.

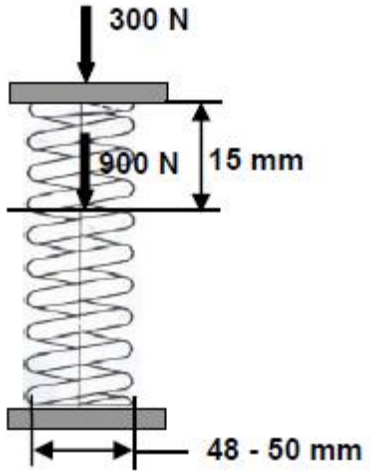
Q11. The engine of a ship develops 440KW and transmits the power by a horizontal propeller shaft which runs at 120rpm. It is proposed to design a hollow shaft with inner diameter as 0.6 of the outer diameter. Considering torsion alone, calculate the diameter of the propeller shaft if stress in the material is not to exceed 63MPa and also the angular twist over length of 2.5m is not to be more than 1°. The modulus of rigidity of the shaft material is 80GPa.

Q12. The internal diameter of a hollow shaft is $2/3^{rd}$ of its external diameter. Compare the strength and stiffness of the shaft with that of a solid shaft of the same material.

MACHINE COMPONENT DESIGN (ME-504)
ASSIGNMENT UNIT-III

Q1. A helical spring of wire diameter 6mm and spring index 6 is acted by an initial load of 800N. After compressing it further by 10mm the stress in the wire is 500MPa. Find the number of active coils. **G** = 84000MPa.

Q2. A helical spring is acted upon by a varying load of 300 N to 900 N respectively as shown in the figure. The spring deflection will be around 15 mm and outside diameter of the spring should be within 48-50 mm. Design the spring.



Q3. Design a leaf spring to carry a load of 3400N and placed over a span of 800 mm. The spring can deflect by 50mm. Consider, allowable bending stress for the spring material as 350 MPa and $E=2\ (10)^5$ MPa.

Q4. Design a closed coiled compression spring for a service load ranging from 2250N to 2750N. The axial deflection of the spring for the total range is 6mm. assume a spring index of 5. The permissible shear stress intensity is 420MPa and modulus of rigidity, G=84 KN/mm^2. Neglect the effect of stress concentration.

Q5. A helical compression spring made of oil tempered carbon steel is subjected to a load which varies from 400N to 1000N. The spring index is 6 and the design factor of safety is 1.25. if the yield stress in shear is 770MPa and endurance stress in shear is 350MPa, find: 1. Size of the spring wire, 2. Diameters of the spring, 3. Number of turns of the spring, and 4. Free length of the spring.

The compression of the spring at the maximum load is 30mm. the modulus of rigidity for the spring material may be taken as 80 KN/mm^2.

Q6. Design a leaf spring for the following specifications: Total load = 140KN; number of springs supporting the load = 4; maximum no. of leaves = 10; span of the spring = 1000mm; permissible deflection = 80mm.
Take young's modulus E=200KN/mm^2 and allowable stress in spring material as 600MPa.

Q7. A semielliptical laminated vehicle spring to carry a load of 6000N is to consist of seven leaves 65mm wide, two of the leaves extending the full length of the spring. The spring is to be 1.1m in length and attached to the axle by two U-bolts 80mm apart. The bolts hold the central portion of the spring so rigidly that they may be considered equivalent to a band having width equal to the distance between the bolts. Assume a design stress for spring material as 350MPa. Determine: 1. Thickness of leaves, 2. Deflection of spring, 3. Diameter of eye, 4. Length of the leaves, and 5. Radius to which leaves should be initially bent.

The standard thickness of leaves are: 5,6,6.5,7,7.5,8,9,10,11etc. in mm

Q8. A leaf spring of quarter elliptical type is required to carry a load of 2000N and to have a length of 500mm. the spring will have 8 graduated and 2 full length leaves. Calculate width and thickness of each spring leaf if ratio of width to thickness is to be 7 and permissible tensile stress is 350N/mm^2. Also calculate deflection. E=200GPa.

Q9. A carbon steel helical coil spring is made from a 12.7mm diameter bar (SWG 7/0). The spring index of spring is 3 and it is subjected to fluctuating load between a maximum of 7000N and a minimum of 5000N. The torsional yield strength and fatigue strength (in reversed shear loading) are respectively 700MPa and 300MPa. Calculate max., minimum, Mean and variable stresses. Also calculate the factor of safety.

Q10. A semielliptical laminated spring is made of 50mm wide and 3mm thick plates. The length between the supports is 650mm and the width of the band is 60mm. the spring has two full length leaves and five graduated leaves. If the spring carries a central load of 1600N, find:

1. Maximum stress in full length and graduated leaves for an initial condition of no stress in leaves.
2. The maximum stress if the initial stress is provided to cause equal stress when loaded.
3. The deflection in parts (1) and (2).

MACHINE COMPONENT DESIGN (ME-504)
ASSIGNMENT UNIT-IV

Q1. A single plate clutch, effective on both sides, is required to transmit 25KW at 3000rpm. Determine the outer and inner diameter of frictional surface if the coefficient of friction is 0.255, ratio of diameter is 1.25 and the maximum pressure is not to exceed 0.1N/mm^2. Also determine the axial thrust to be provided by springs. Assume theory of uniform wear.

Q2. A single dry plate clutch is to be designed to transmit 7.5KW at 900rpm. Find:

1. Diameter of shaft
2. Mean radius and face width of the friction lining assuming the ratio of the mean radius to the face width as 4,
3. Outer and inner radii of the clutch plate,
4. Dimensions of the spring, assuming that the number of springs are 6 and spring index=6. The allowable shear stress for the spring wire may be taken as 420MPa.

Q3. A multi disc clutch, steel on bronze, is to transmit 4.5 KW at 750rpm. The inner radius of the contact is 40mm and outer radius of the contact is 70mm.The clutch operation in oil with an expected coefficient of 0.1. The average allowable pressure is 0.35N/mm^2. Find:

1. The total number of steel and bronze discs,
2. The actual axial force required
3. The actual average pressure
4. The actual maximum pressure.

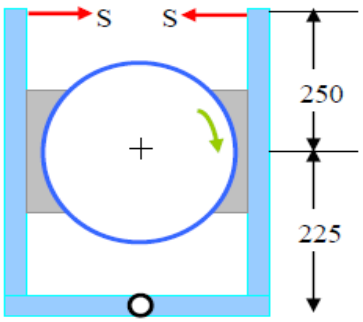
Q4. Determine the principal dimensions of a cone clutch faced with leather to transmit 30KW at 750rpm from an electric motor to an air compressor.

Assume: semi-angle of the cone=$12\frac{1}{2}°$; $\mu = 0.2$; mean diameter of cone=6 to 10d where d is the diameter of shaft; allowable normal pressure for leather and cast iron=0.075 to 0.1N/mm^2; load factor=1.75 and mean diameter to face width ratio=6.

Q5. A centrifugal clutch is to be designed to transmit 15 KW at 900 rpm. The shoes are four in number. The speed at which the engagement begins is 3/4th of the running speed. The inside radius of the pulley rim is 150mm. the shoes are lined with ferrodo for which the coefficient of friction may be taken as 0.25. Determine:

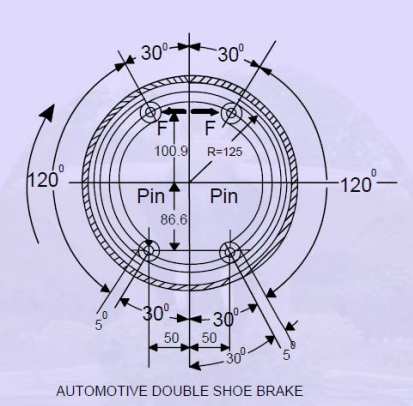
1. Mass of the shoes,
2. Size of the shoes.

Q6.A double shoe brake has diameter of brake drum 300mm and contact angle of each shoe 90 degrees, as shown in figure below. If the coefficient of friction for the brake lining and the drum is 0.4, find the spring force necessary to transmit a torque of 30 Nm. Also determine the width of the brake shoe if the braking pressure on the lining material is not to exceed 0.28 MPa.



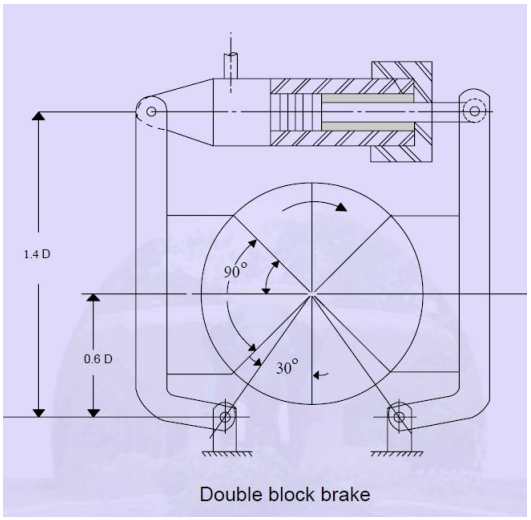
Q7. A differential band brake has brake drum of diameter 500mm and the maximum torque on the drum is 1000 N-m. The brake embraces 2/3rd of the circumference. If the band brake is lined with asbestos fabric having a coefficient of friction 0.3, then design the steel band. The permissible stress is 70 MPa in tension. The bearing pressure for the brake lining should not exceed 0.2 MPa.

Q8.An improved lining material is being tried on an existing passenger car drum brake shown in Figure. Quality tests on the material indicated permissible pressure of 1.0 MPa and friction co-efficient of 0.32. Determine what maximum actuating force can be applied for a lining width of 40 mm and the corresponding braking torque that could be developed. While cruising on level road at 100 kmph, if it is to decelerated at 0.5g and brought to rest, how much energy is absorbed and what is the expected stopping distance?



AUTOMOTIVE DOUBLE SHOE BRAKE

Q9.A spring set, hydraulically released double shoe drum brake, schematically shown at Fig 2 is to be designed to have a torque capacity of 600 N.m under almost continuous duty when the brake drum is rotating at 400 rpm in either direction. Assume that the brake lining is to be molded asbestos having a friction coefficient of 0.3 and permissible pressure of 0.8 MPa. The width of the brake shoe is to be third of drum diameter and the remaining proportion's are as shown in figure.



Double block brake

Q10. A band brake acts on the $3/4^{th}$ of circumference of a drum of 450mm diameter which is keyed to the shaft. The band brake provides a braking torque of 225 N-m. One end of the band is attached to a fulcrum pin of the lever and the other end to a pin 100 mm from the fulcrum. If the operating force applied at 500 mm from the fulcrum and the coefficient of friction is 0.25, find the operating force when the drum rotates in the anticlockwise direction.

If the brake lever and pins are to be made of mild steel having permissible stresses for tension and crushing as 70MPa and for shear 56MPa, design the shaft, key, lever and pins. The bearing pressure between the pin and the lever may be taken as $8N/mm^2$.

MACHINE COMPONENT DESIGN (ME-504)
ASSIGNMENT UNIT-V

Q1. A simply supported shaft, diameter 50mm, on bearing supports carries a load of 10kN at its center. The axial load on the bearings is 3kN. The shaft speed is 1440 rpm. Select a bearing for 1000 hours of operation.

Q2.In a journal bearing application an oil of kinematic viscosity at 100oC corresponding to 46 seconds as found from Saybolt viscometer is used. Determine its absolute viscosity and corresponding oil in SAE and ISO VG grades.

Q3. A journal of a stationary oil engine is 80 mm in diameter and 40 mm long. The radial clearance is 0.060mm. It supports a load of 9 kN when the shaft is rotating at 3600 rpm. The bearing is lubricated with SAE 40oil supplied at atmospheric pressure and average operating temperature is about 65oC. Using Raimondi- Boyd charts analyze the bearing assuming that it is working under steady state condition.

Q4. A journal bearing of a centrifugal pump running at 1740 rpm has to support a steady load of 8kN. The journal diameter from trial calculation is found to be 120 mm. Design suitable journals bearing for the pump to operate under hydrodynamic condition.

Q5. A bush bearing has to operate under boundary lubricated condition with a radial load of 150 N and speed of 4 rps. Its wear should be less than 0.03 mm in 5000 h of operation. Maximum operating temperature is 85°C. Factor of safety desired is 2. Choose suitable oils bearing for the application. Assume an air temperature of 30O°C.Take k = 15.3 W/m2. °C

Q6. Design a journal bearing for a centrifugal pump from the following data: load on the journal =20000N; speed of the journal =900 rpm; type of oil is SAE 10, for which the absolute viscosity at 55°C=0.017kg/m-s; ambient temperature of oil = 15.5°C; maximum bearing pressure for the pump = 1.5N/mm^2.

Calculate also mass of the lubricating oil required for artificial cooling, if rise of temperature of oil be limited to 10°C. Heat dissipation coefficient=1232 W/m^2/ °C.

Q7. Select a single row deep groove ball bearing for a radial load of 4000N and an axial load of 5000N, operating at a speed of 1600 rpm for an average life of 5 years at 10 hours per day. Assume uniform and steady load.

Q8. A ball bearing subjected to a radial load of 5 KN is expected to have a life of 8000 hours at 1450 rpm with a reliability of 99%. Calculate the dynamic load capacity of the bearing so that it can be selected from the manufacturer's catalogue based on reliability of 90%.

Q9. A single row deep groove ball bearing operating at 2000 rpm is acted by a 10KN radial load and 8KN thrust load. The bearing is subjected to a light shock load and the outer ring is rotating. Determine the rating life of the bearing.

Q10. A certain ball bearing has single row in which 12 balls of 16mm diameter are arranged. Calculate the basic statics capacity.