Thilina H. Weerakkody
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Tutorial 5 - Design of Screwed Joints

Q1. An eye bolt is to be used for lifting a load of 60kN. Find the normal diameter of the bolt, if the tensile stress is not to exceed 100 MPa. Assume coarse thread.

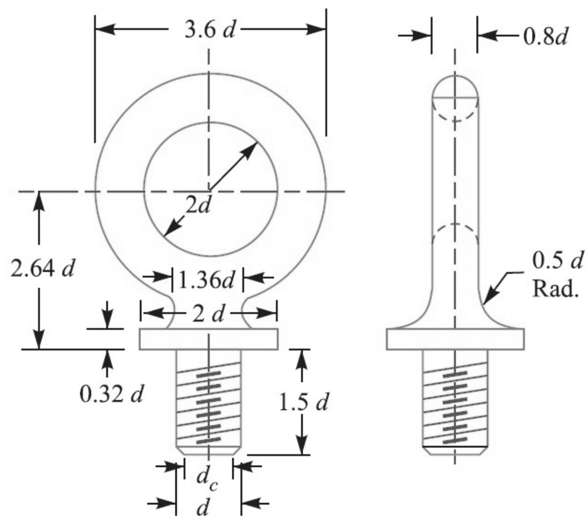

Figure 1: Lifting Eye Bolt

Q2. Two shafts are connected by means of a flange coupling to transmit torque of 25 N-m. The flanges of the coupling are fastened by four bolts of the same material at a radius of 30 mm. Find the size of the bolts if the allowable shear stress for the bolt material is 30 MPa.

Q3. A lever loaded safety valve has a diameter of 100 mm and the blow off pressure is 1.6 N/mm^2. The fulcrum of the lever is screwed into the cast iron body of the cover. Find the diameter of the threaded part of the fulcrum if the permissible tensile stress is limited to 50 MPa and the leverage ratio is 8.

Q4. The cylinder head of a steam engine is subjected to a steam pressure of 0.7 N/mm2. It is held in position by means of 12 bolts. A soft copper gasket is used to make the joint leak-proof. The effective diameter of cylinder is 300 mm. Find the size of the bolts so that the stress in the bolts is not to exceed 100 MPa.

Q5. The largest diameter of an external or internal screw thread is known as

(**a**) minor diameter
(**b**) major diameter
(**c**) pitch diameter
(**d**) none of these

Q6. The pitch diameter is the .... diameter of an external or internal screw thread.

(**a**) effective (**b**) smallest
(**c**) largest

Q7. A screw is specified by its

(**a**) major diameter (**b**) minor diameter
(**c**) pitch diameter (**d**) pitch

Q8. The square threads are usually found on

(**a**) spindles of bench vices (**b**) railway carriage couplings
(**c**) feed mechanism of machine tools (**d**) screw cutting lathes

Q9. The washer is generally specified by its

(**a**) outer diameter (**b**) hole diameter
(**c**) thickness (**d**) mean diameter

Q10. A locking device extensively used in automobile industry is a

(**a**) jam nut (**b**) castle nut
(**c**) screw nut (**d**) ring nut

Q11. A bolt of M 24 × 2 means that

(**a**) the pitch of the thread is 24 mm and depth is 2 mm

(**b**) the cross−sectional area of the threads is 24 mm^2

(**c**) the nominal diameter of bolt is 24 mm and the pitch is 2 mm

(**d**) the effective diameter of the bolt is 24 mm and there are two threads per cm

Q12. When a nut is tightened by placing a washer below it, the bolt will be subjected to

(**a**) tensile stress (**b**) compressive stress
(**c**) shear stress (**d**) none of these

Q13. The eye bolts are used for

(**a**) transmission of power (**b**) locking devices
(**c**) lifting and transporting heavy machines (**d**) absorbing shocks and vibrations

Q14. The shock absorbing capacity of a bolt may be increased by

(**a**) increasing its shank diameter

(**b**) decreasing its shank diameter

(**c**) tightening the bolt properly

(**d**) making the shank diameter equal to the core diameter of the thread.

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Tutorial 6 – Design of Power Screws (In-class test)

Duraion: 45 Minutes

- Paper consists **SEVEN** questions in **TWO** pages.
- Answer **ALL** questions.
- Attach the question paper along with your answer script.
- Write your answers in separate sheets.
- This is an **CLOSED BOOK** examination.
- **Write short answers in point form**.

Q1. State **three** applications (machines) of power-screws. (03 marks)

Q2. Sketch the following power screw thread patterns. Identify (mark) the pitch and depth of screw in the drawn sketch.
(a) Screw thread, (b) ACME Trapezoidal thread, (c) Buttress Thread (12 marks)

Q3. Draw the force lines for the ***thrust bearing collar section*** shown in Figure 1. (05 marks)

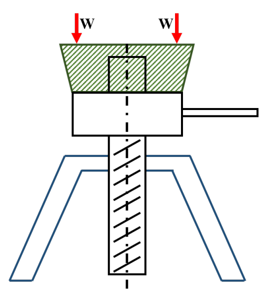

Figure 1: Draw the force flow lines

Q4. Define following terms (You may use sketches along with explanation).

(a) Major diameter (d)

(b) Minor diameter (d_m)

(c) Pitch diamter (d_p)

(d) Lead (L)

(e) Helix angle (05 marks)

Q5. Recall torque required to Raise (Nut moves up through thread) load by square threaded screws. Obtain an expression for **P**−***Effort applied at the circumference of the screw to lift the load*** using W, α, ϕ. $\alpha-$ Helix angle, $\mu = \tan\phi$
Use the resolving forces along and perpendicular to the plane method
(i.e. Applying Newton's Law or method available in the handout)

(10 marks)

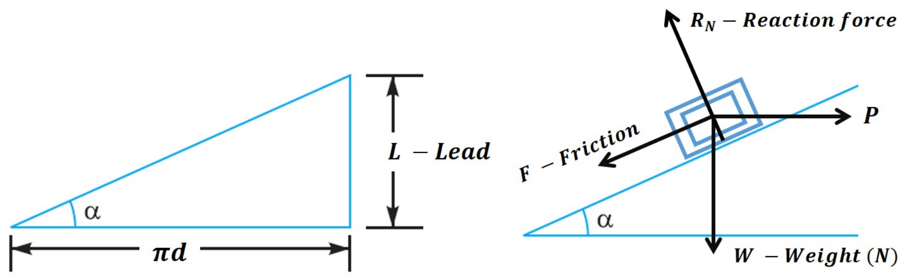

Figure 2: Lifting the load

Q6. For the above question scenario, obtain an expression for Efficiency (η) of square threaded screws consists only α, ϕ terms
where $\alpha-$ Helix angle and $\phi-$Friction angle. (05 marks)

Q7. ***Deduce*** - state the equation based on given equations without proving using fundamentals.
Deduce an expression to calculate the Torque(T) requirement to tension and loosen the turnbuckle shown in Figure 3.
The diameters of screwed threaded shafts A and B are d_{m_A} and d_{m_B} respectively. Friction angles are ϕ_A and ϕ_B. Helix angles are α_A and α_B.

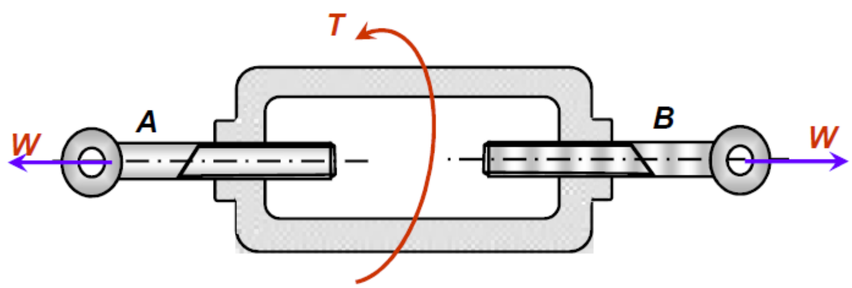

Figure 3: Turnbuckle Type 1

(10 marks)

Note:
Force required to tension a turnbuckle. P=Wtan$(\phi + \alpha)$
Force required to loosen a turnbuckle. P=Wtan$(\phi - \alpha)$

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Tutorial 6 – Design of Power Screws (In-class test)

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Q3. Draw the force lines for the ***thrust bearing collar section*** shown in Figure 1. (05 marks)

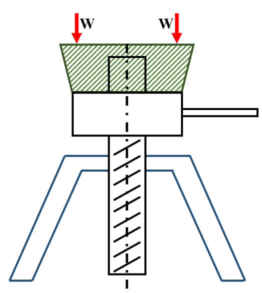

Figure 1: Draw the force flow lines

Q4. Define following terms (You may use sketches along with explanation).

(a) Major diameter (d)
(b) Minor diameter (d_m)
(c) Pitch diamter (d_p)
(d) Lead (L)
(e) Helix angle (05 marks)

Q5. Recall torque required to Raise (Nut moves up through thread) load by square threaded screws. Obtain an expression for **P**$-$***Effort applied at the circumference of the screw to lift the load*** using W, α, ϕ. $\alpha-$ Helix angle, $\mu = \tan\phi$
Apply ***Lami's theorem*** or ***Sine Rule*** (10 marks)

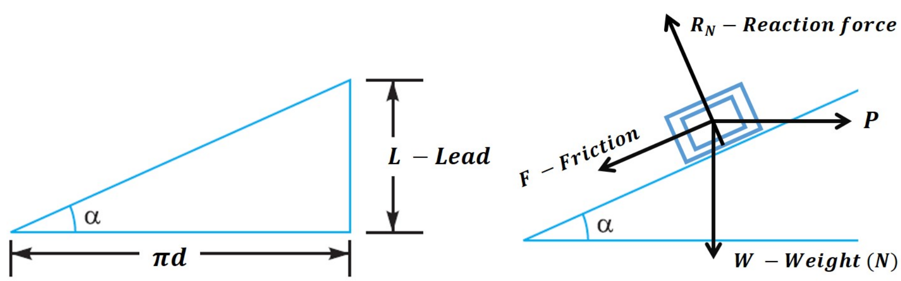

Figure 2: Lifting the load

Q6. For the above question scenario, obtain an expression for Efficiency (η) of square threaded screws consists only α, ϕ terms
where $\alpha-$ Helix angle and $\phi-$Friction angle. (05 marks)

Q7. ***Deduce*** means state the equation based on given equations without proving using fundamentals.
Deduce an expression to calculate the Torque(T) requirement to rising and lowering the differential screw jack shown in Figure 3.
The diameters of screwed threaded shafts A and B are d_{m_A} and d_{m_B} respectively. Friction angles are ϕ_A and ϕ_B. Helix angles are α_A and α_B.

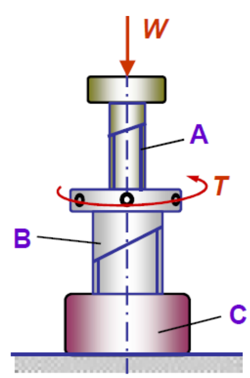

Figure 3: Differential screw jack

(10 marks)

Note:
Force required to rise the square threaded power screw. P=Wtan$(\phi + \alpha)$
Force required to lower the square threaded power screw. P=Wtan$(\phi - \alpha)$

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Tutorial 6 – Design of Power Screws (In-class test)

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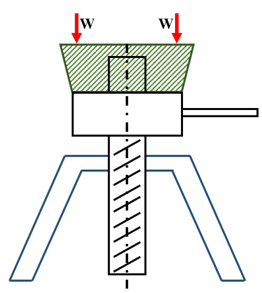
Q3. Draw the force lines for the ***thrust bearing collar section*** shown in Figure 1. (05 marks)



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(a) Major diameter (d)

(b) Minor diameter (d_m)

(c) Pitch diamter (d_p)

(d) Lead (L)

(e) Helix angle (05 marks)

Q5. Recall torque required to Lower (Nut moves down through thread) load by square threaded screws. Obtain an expression for **P**$-$***Effort applied at the circumference of the screw to lower the load*** using W, α, ϕ. $\alpha-$ Helix angle, $\mu = \tan\phi$
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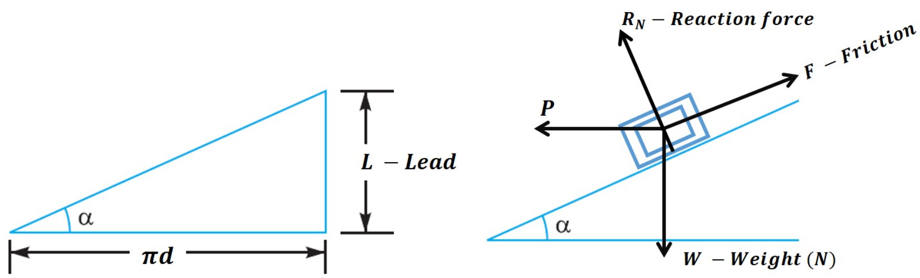

Figure 2: Lowering Power Screw

(10 marks)

Q6. For the above question scenario, obtain an expression for Efficiency (η) of square threaded screws consists only α, ϕ terms
where $\alpha-$ Helix angle and $\phi-$Friction angle. (05 marks)

Q7. ***Deduce*** - state the equation based on given equations without proving using fundamentals.
Deduce an expression to calculate the Torque(T) requirement to tension and loosen the turnbuckle shown in Figure 3.
The diameters of screwed threaded shafts is d_m. Friction angle is ϕ. Helix angle is α.

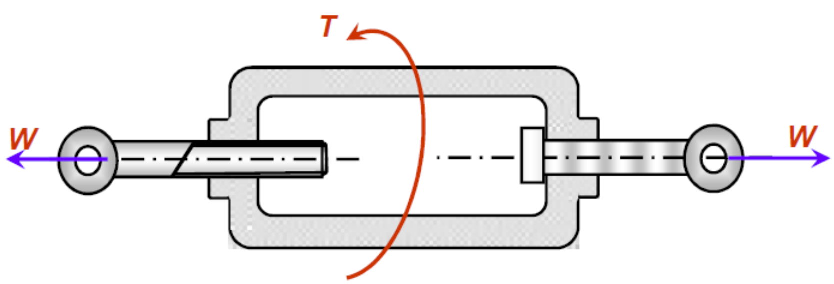

Figure 3: Turnbuckle Type 2

(10 marks)

Note:
Force required to tension a turnbuckle. P=Wtan$(\phi + \alpha)$
Force required to loosen a turnbuckle. P=Wtan$(\phi - \alpha)$

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Tutorial 6 – Design of Power Screws (In-class test)

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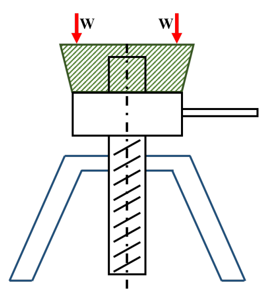

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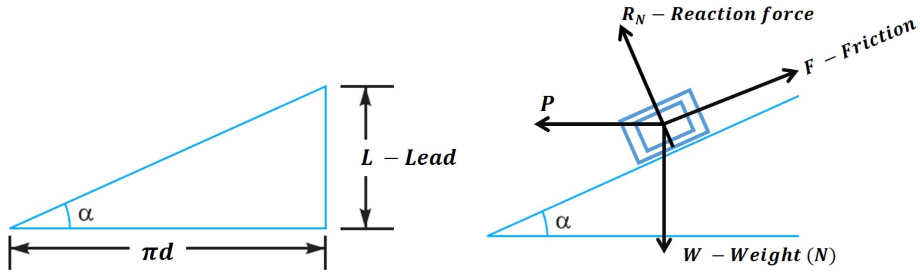

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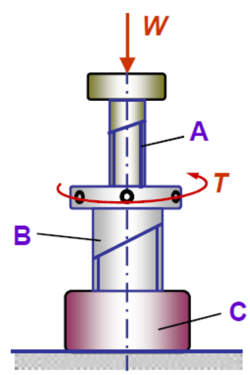

Figure 3: Differential screw jack

(10 marks)

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Tutorial 6 – Design of Power Screws

Q1. A vertical screw with single start square threads of 50 mm mean diameter and 12.5 mm pitch is raised against a load of 10 kN by means of a hand wheel, the boss of which is threaded to act as a nut. The axial load is taken up by a thrust collar which supports the wheel boss and has a mean diameter of 60 mm. The coefficient of friction is 0.15 for the screw and 0.18 for the collar. If the tangential force applied by each hand to the wheel is 100 N, find suitable diameter of the hand wheel.

Q2. An electric motor driven power screw moves a nut in a horizontal plane against a force of 75 kN at a speed of 300 mm/min. The screw has a single square thread of 6 mm pitch on a major diameter of 40 mm. The coefficient of friction at screw threads is 0.1. Estimate power of the motor.

Q3. The cutter of a broaching machine is pulled by square threaded screw of 55 mm external diameter and 10 mm pitch. The operating nut takes the axial load of 400 N on a flat surface of 60 mm and 90 mm internal and external diameters respectively. If the coefficient of friction is 0.15 for all contact surfaces on the nut, determine the power required to rotate the operating nut when the cutting speed is 6 m/min. Also find the efficiency of the screw.

Q4. A vertical two start square threaded screw of a 100 mm mean diameter and 20 mm pitch supports a vertical load of 18 kN. The axial thrust on the screw is taken by a collar bearing of 250 mm outside diameter and 100 mm inside diameter. Find the force required at the end of a lever which is 400 mm long in order to lift and lower the load. The coefficient of friction for the vertical screw and nut is 0.15 and that for collar bearing is 0.20.

Q5. The mean diameter of the square threaded screw having pitch of 10 mm is 50 mm. A load of 20 kN is lifted through a distance of 170 mm. Find the work done in lifting the load and the efficiency of the screw, when

1. The load rotates with the screw, and
2. The load rests on the loose head which does not rotate with the screw

The external and internal diameter of the bearing surface of the loose head are 60 mm and 10 mm respectively. The coefficient of friction for the screw and the bearing surface may be taken as 0.08.

Q6. A power screw having double start square threads of 25 mm nominal diameter and 5 mm pitch is acted upon by an axial load of 10 kN. The outer and inner diameters of screw collar are 50 mm and 20 mm respectively. The coefficient of thread friction and collar friction may be assumed as 0.2 and 0.15 respectively. The screw rotates at 12 r.p.m. Assuming uniform wear condition at the collar and allowable thread bearing pressure of 5.8 N/mm2, find: 1. the torque required to rotate the screw; 2. the stress in the screw; and 3. the number of threads of nut in engagement with screw.

Q7. The screw of a shaft straightener exerts a load of 30 kN as shown in Fig. 1. The screw is square threaded of outside diameter 75 mm and 6 mm pitch. Determine:

1. Force required at the rim of a 300 mm diameter hand wheel, assuming the coefficient of friction for the threads as 0.12
2. Maximum compressive stress in the screw, bearing pressure on the threads and maximum shear stress in threads
3. Efficiency of the straightner

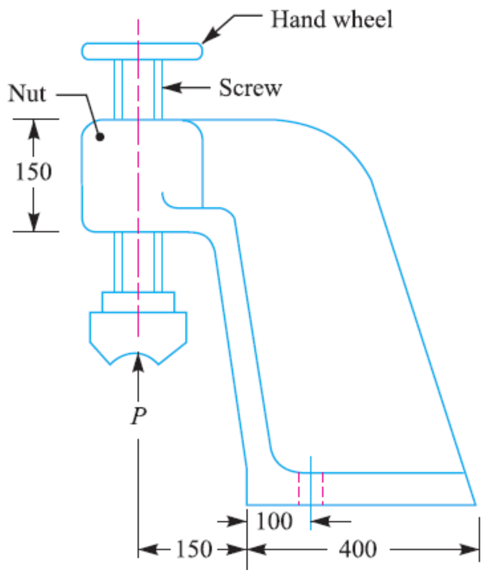

Figure 1

Q8. A sluice gate weighing 18 kN is raised and lowered by means of square threaded screws, as shown in Fig. 2. The frictional resistance induced by water pressure against the gate when it is in its lowest position is 4000 N. The outside diameter of the screw is 60 mm and pitch is 10 mm. The outside and inside diameter of washer is 150 mm and 50 mm respectively. The coefficient of friction between the screw and nut is 0.1 and for the washer and seat is 0.12. Find :

1. The maximum force to be exerted at the ends of the lever raising and lowering the gate
2. Efficiency of the arrangement
3. Number of threads and height of nut, for an allowable bearing pressure of 7 N/mm2.

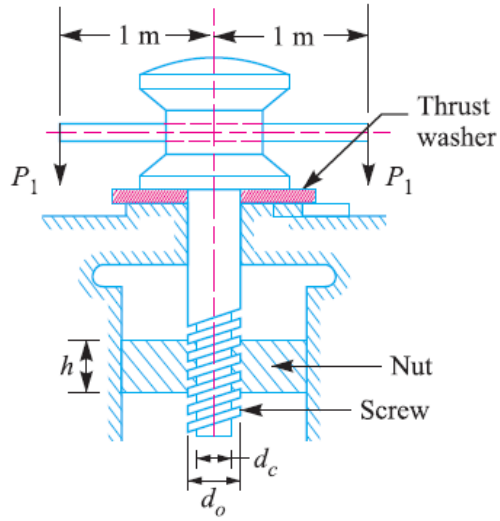

Figure 2

Q9. The screw, as shown in Fig. 3 is operated by a torque applied to the lower end. The nut is loaded and prevented from turning by guides. Assume friction in the ball bearing to be negligible. The screw is a triple start trapezoidal thread. The outside diameter of the screw is 48 mm and pitch is 8 mm. The coefficient of friction of the threads is 0.15. Find :

1. Load which can be raised by a torque of 40 N-m
2. Whether the screw is overhauling
3. Average bearing pressure between the screw and nut thread surface.

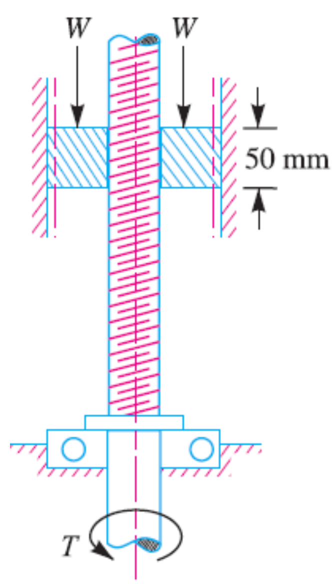

Figure 3

Q10. C-clamp, as shown in Fig. 4, has trapezoidal threads of 12 mm outside diameter and 2 mm pitch. The coefficient of friction for screw threads is 0.12 and for the collar is 0.25. The mean radius of the collar is 6 mm. If the force exerted by the operator at the end of the handle is 80 N, find:

1. The length of handle
2. The maximum shear stress in the body of the screw and where does this exist
3. The bearing pressure on the threads.

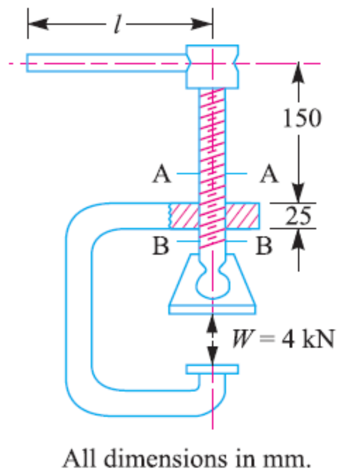

Figure 4

Tutorial 6 – Design of Power Screws – Calculations (In-class test)

Duraion: 45 Minutes

- This is an **OPEN BOOK** examination. Answer to the **BOTH** questions.
- Attach your question paper along with your answer scripts.
- Clearly state your assumptions and write your equations.

Q1. The lead screw of a lathe has square threads of 24 mm outside diameter and 5 mm pitch. In order to drive the tool carriage, the screw exerts an axial pressure of 2.5 kN. Find the efficiency of the screw and the power required to drive the screw, if it is to rotate at 30 r.p.m. Neglect bearing friction. Assume coefficient of friction of screw threads as 0.12. (25 marks)

Q2. A sluice gate weighing 18 kN is raised and lowered by means of square threaded screws, as shown in Fig. 1. The frictional resistance induced by water pressure against the gate when it is in its lowest position is 4000 N. The outside diameter of the screw is 60 mm and pitch is 10 mm. The outside and inside diameter of washer is 150 mm and 50 mm respectively. The coefficient of friction between the screw and nut is 0.1 and for the washer and seat is 0.12. Find : (25 marks)

1. The maximum force to be exerted at the ends of the lever raising and lowering the gate
2. Efficiency of the arrangement
3. Number of threads and height of nut, for an allowable bearing pressure of 7 N/mm2.

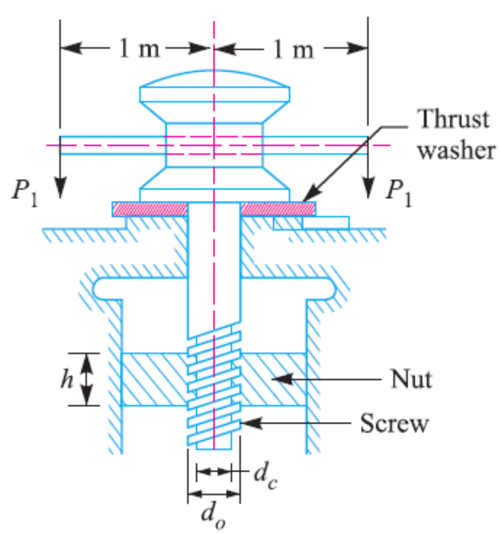

Figure 1

Tutorial 6 – Design of Power Screws – Calculations (In-class test)

Duraion: 45 Minutes

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Q1. A sluice valve, used in water pipe lines, consists of a gate raised by the spindle, which is rotated by the hand wheel. The spindle has single start square threads. The nominal diameter of the spindle is 36 mm and the pitch is 6 mm. The friction collar has inner and outer diameters of 32 mm and 50 mm respectively. The coefficient of friction at the threads and the collar are 0.12 and 0.18 respectively. The weight of the gate is 7.5 kN and the frictional resistance to open the valve due to water pressure is 2.75 kN. Using uniform wear theory, determine : 1. torque required to raise the gate; and 2. overall efficiency. (25 marks)

Q2. The screw, as shown in Fig. 1 is operated by a torque applied to the lower end. The nut is loaded and prevented from turning by guides. Assume friction in the ball bearing to be negligible. The screw is a triple start trapezoidal thread. The outside diameter of the screw is 48 mm and pitch is 8 mm. The coefficient of friction of the threads is 0.15. Find : (25 marks)

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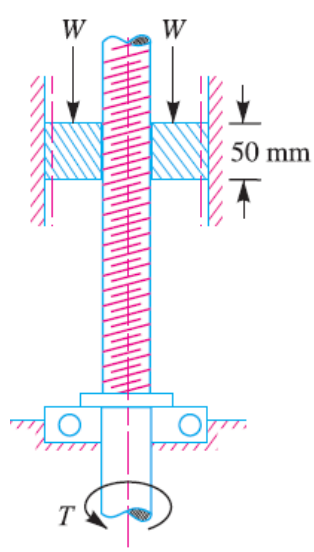

Figure 1

Tutorial 6 – Design of Power Screws – Calculations (In-class test)

Duraion: 45 Minutes

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Q1. A cross bar of a planer weighing 9 kN is raised and lowered by means of two square threaded screws of 40 mm outside diameter and 6 mm pitch. The screw is made of steel and nut of phosphor bronze having 42 mm height. A steel collar bearing with 30 mm mean radius takes the axial thrust. The coefficient of friction at the threads and at the collar may be assumed as 0.14 and 0.10 respectively. Find the force required at a radius of 120 mm of a hand wheel to raise and lower the load. Find also the shear stress in the nut material and the bearing pressure on the threads. (25 marks)

Q2. C-clamp, as shown in Fig. 1, has trapezoidal threads of 12 mm outside diameter and 2 mm pitch. The coefficient of friction for screw threads is 0.12 and for the collar is 0.25. The mean radius of the collar is 6 mm. If the force exerted by the operator at the end of the handle is 80 N, find: (25 marks)

1. The length of handle
2. The maximum shear stress in the body of the screw and where does this exist
3. The bearing pressure on the threads.

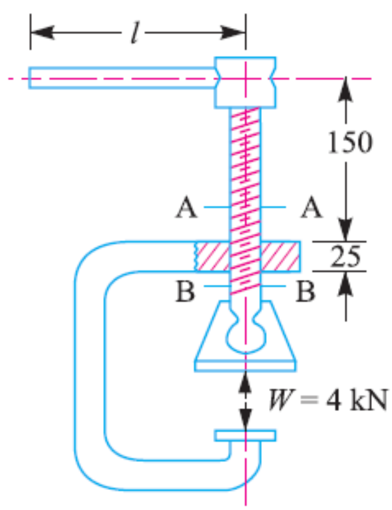

Figure 1

Tutorial 6 – Design of Power Screws – Calculations (In-class test)

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1. The maximum force to be exerted at the ends of the lever raising and lowering the gate
2. Efficiency of the arrangement
3. Number of threads and height of nut, for an allowable bearing pressure of 7 N/mm2.

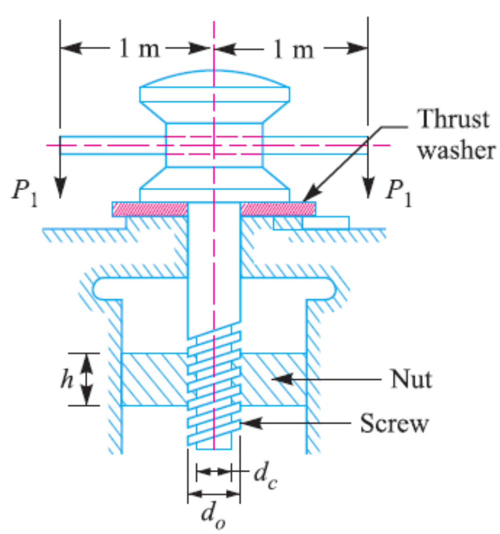


Figure 1

Tutorial 6 – Design of Power Screws – Calculations (In-class test)

Duraion: 45 Minutes

- This is an **OPEN BOOK** examination. Answer to the **BOTH** questions.
- Attach your question paper along with your answer scripts.
- Clearly state your assumptions and write your equations.

Q1. A sluice valve, used in water pipe lines, consists of a gate raised by the spindle, which is rotated by the hand wheel. The spindle has single start square threads. The nominal diameter of the spindle is 36 mm and the pitch is 6 mm. The friction collar has inner and outer diameters of 32 mm and 50 mm respectively. The coefficient of friction at the threads and the collar are 0.12 and 0.18 respectively. The weight of the gate is 7.5 kN and the frictional resistance to open the valve due to water pressure is 2.75 kN. Using uniform wear theory, determine : 1. torque required to raise the gate; and 2. overall efficiency. (25 marks)

Q2. The screw, as shown in Fig. 1 is operated by a torque applied to the lower end. The nut is loaded and prevented from turning by guides. Assume friction in the ball bearing to be negligible. The screw is a triple start trapezoidal thread. The outside diameter of the screw is 48 mm and pitch is 8 mm. The coefficient of friction of the threads is 0.15. Find : (25 marks)

1. Load which can be raised by a torque of 40 N-m
2. Whether the screw is overhauling
3. Average bearing pressure between the screw and nut thread surface.

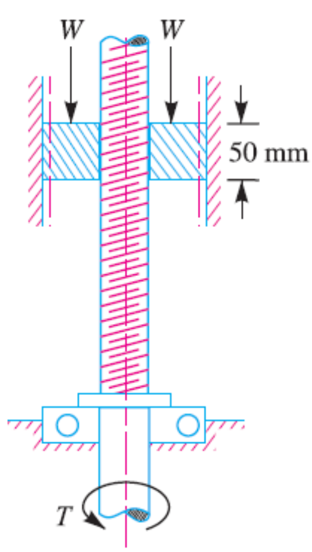


Figure 1

Tutorial 6 – Design of Power Screws – Calculations (In-class test)

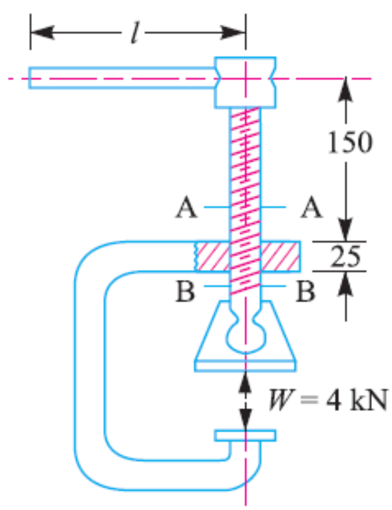
Duraion: 45 Minutes

- This is an **OPEN BOOK** examination. Answer to the **BOTH** questions.
- Attach your question paper along with your answer scripts.
- Clearly state your assumptions and write your equations.

Q1. A cross bar of a planer weighing 9 kN is raised and lowered by means of two square threaded screws of 40 mm outside diameter and 6 mm pitch. The screw is made of steel and nut of phosphor bronze having 42 mm height. A steel collar bearing with 30 mm mean radius takes the axial thrust. The coefficient of friction at the threads and at the collar may be assumed as 0.14 and 0.10 respectively. Find the force required at a radius of 120 mm of a hand wheel to raise and lower the load. Find also the shear stress in the nut material and the bearing pressure on the threads. (25 marks)

Q2. C-clamp, as shown in Fig. 1, has trapezoidal threads of 12 mm outside diameter and 2 mm pitch. The coefficient of friction for screw threads is 0.12 and for the collar is 0.25. The mean radius of the collar is 6 mm. If the force exerted by the operator at the end of the handle is 80 N, find: (25 marks)

1. The length of handle
2. The maximum shear stress in the body of the screw and where does this exist
3. The bearing pressure on the threads.



All dimensions in mm.

Figure 1

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Tutorial 7 - Design of Welded Joints

Q1. A plate 100 mm wide and 10 mm thick is to be welded to another plate by means of double parallel fillets. The plates are subjected to a static load of 80 kN. Find the length of weld if the permissible shear stress in the weld does not exceed 55 MPa.

Q2. A 50 mm diameter solid shaft is welded to a flat plate by 10 mm fillet weld as shown in Fig. 1. Find the maximum torque that the welded joint can sustain if the maximum shear stress intensity in the weld material is not to exceed 80 MPa.

Q3. A plate 1 m long, 60 mm thick is welded to another plate at right angles to each other by 15 mm fillet weld, as shown in Fig. 2. Find the maximum torque that the welded joint can sustain if the permissible shear stress intensity in the weld material is not to exceed 80 MPa.

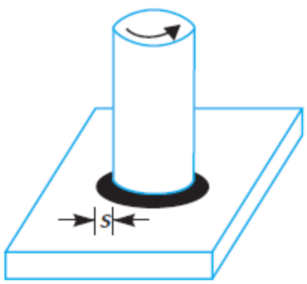

Figure 1

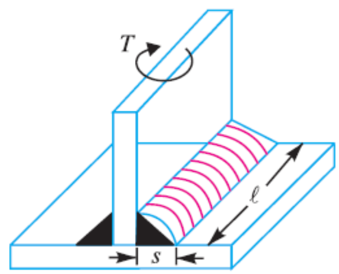

Figure 2

Q4. A 200 × 150 × 10 mm angle is to be welded to a steel plate by fillet welds as shown in Fig. 3. If the angle is subjected to a static load of 200 kN, find the length of weld at the top and bottom. The allowable shear stress for static loading may be taken as 75 MPa.

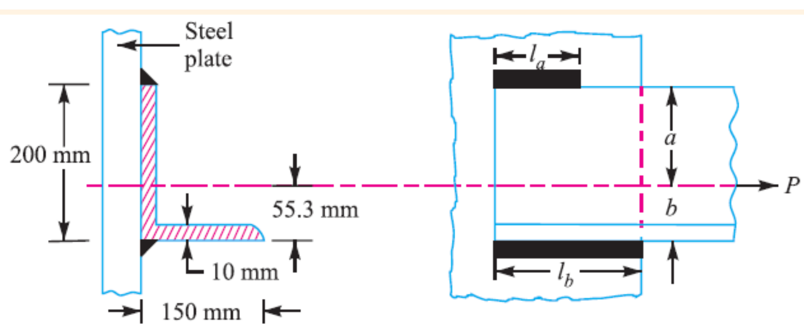

Figure 3

Q5. A welded joint as shown in Fig. 4, is subjected to an eccentric load of 2 kN. Find the size of weld, if the maximum shear stress in the weld is 25 MPa.

Q6. A 50 mm diameter solid shaft is welded to a flat plate as shown in Fig. 5. If the size of the weld is 15 mm, find the maximum normal and shear stress in the weld.

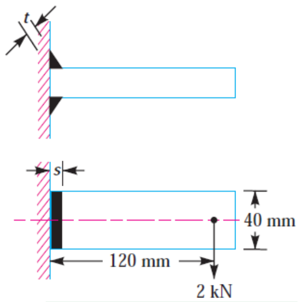

Figure 4

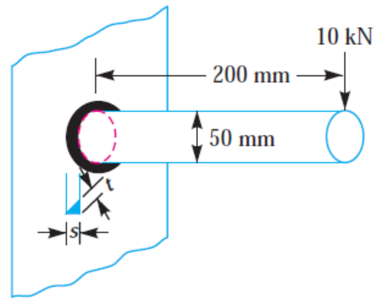

Figure 5

Q7. A rectangular cross-section bar is welded to a support by means of fillet welds as shown in Fig. 6. Determine the size of the welds, if the permissible shear stress in the weld is limited to 75 MPa.

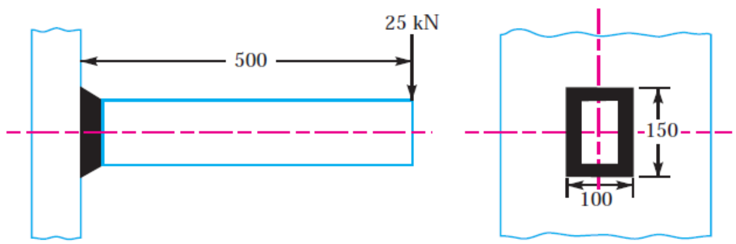

Figure 6

Q8. An arm A is welded to a hollow shaft at section '1'. The hollow shaft is welded to a plate C at section '2'. The arrangement is shown in Fig. 7, along with dimensions. A force P = 15 kN acts at arm A perpendicular to the axis of the arm. Calculate the size of weld at section '1' and '2'. The permissible shear stress in the weld is 120 MPa.

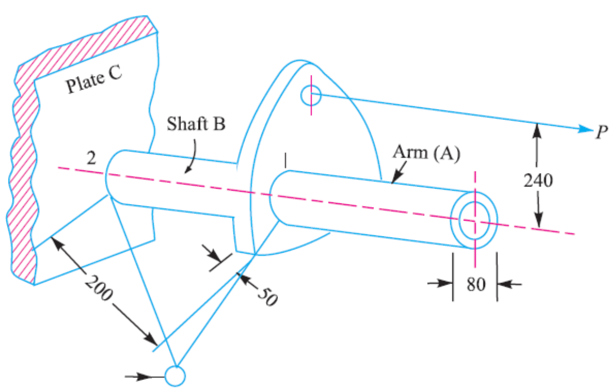

Figure 7

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Tutorial 8 - Reliability & Statistics

Q1. Bolts installed on a production line are tightened with automatic wrenches. They are to be tightened sufficiently to yield the full cross section in order to produce the highest possible initial tension. The limiting condition is twisting off the bolts during assembly. The bolts have a mean twisting-off strength of 20 Nm with a standard deviation of 1 Nm. The automatic wrenches have a standard deviation of 1.5 Nm. What mean value of wrench torque setting would result in an estimated 1 bolt in 500 twisting off during assembly (see Figure 1)?

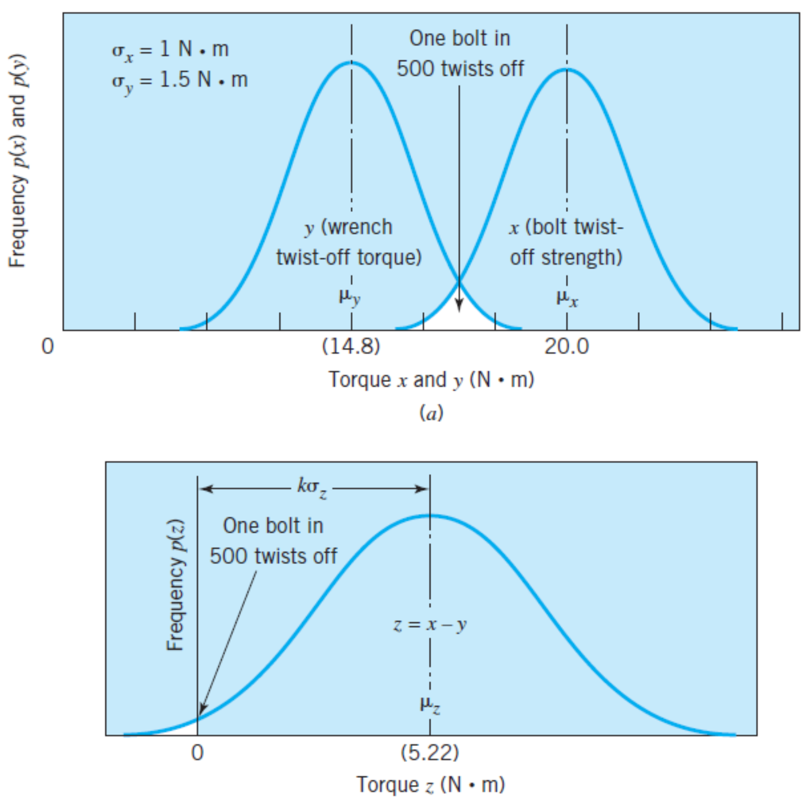

Figure 1: Q1

(Answers $\sigma_z = 1.80$ Nm, Percentage = 1/500= 20%, $\mu_z = 5.22$ Nm, $\mu_y = 14.78$ Nm)

Q2. A shaft is subjected to a maximum load of 10 kN. It is designed to withstand a load of 15 kN. If the maximum load encountered is normally distributed with a standard deviation of 2.5 kN, and if shaft strength is normally distributed with a standard deviation of 2.0 kN, what failure percentage would be expected? [Ans.: 7.0%]

Q3. Assume that the failure rate calculated in Q2 is unacceptable.
(a) To what value would the standard deviation of shaft strength have to be reduced in order to give a failure rate of only 3%, with no other changes?
(b) To what value would the nominal shaft strength have to be increased in order to give a failure rate of only 3%, with no other changes?

Q4. A particular machine part is subjected in service to a maximum load of 10 kN. With the thought of providing a safety factor of 1.5, it is designed to withstand a load of 15 kN. If the maximum load encountered in various applications is normally distributed with a standard deviation of 2 kN, and if part strength is normally distributed with a standard deviation of 1.5 kN, what failure percentage would be expected in service?[Ans.: 2.3%]

Q5. Assume that the failure rate calculated in Q4 is unacceptable.
(a) To what value would the standard deviation of part strength have to be reduced in order to give a failure rate of only 1%, with no other changes?
(b) To what value would the nominal part strength have to be increased in order to give a failure rate of only 1%, with no other changes?

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Tutorial 9 – Design of Shafts

Q1. A shaft made of mild steel is required to transmit 100 kW at 300 r.p.m. The supported length of the shaft is 3 meters. It carries two pulleys each weighing 1500 N supported at a distance of 1 meter from the ends respectively. Assuming the safe value of stress, determine the diameter of the shaft.

Q2. 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. 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 pressure FtC of the gear C and FtD of 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 gears 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.

Q3. A hoisting drum 0.5 m in diameter is keyed to a shaft which is supported in two bearings and driven through a 12 : 1 reduction ratio by an electric motor. Determine the power of the driving motor, if the maximum load of 8 kN is hoisted at a speed of 50 m/min and the efficiency of the drive is 80%. Also determine the torque on the drum shaft and the speed of the motor in r.p.m.
Determine also the diameter of the shaft made of machinery steel, the working stresses of which are 115 MPa in tension and 50 MPa in shear. The drive gear whose diameter is 450 mm is mounted at the end of the shaft such that it overhangs the nearest bearing by 150 mm. The combined shock and fatigue factors for bending and torsion may be taken as 2 and 1.5 respectively.

Review – (In-class test) Duraion: 50 Minutes

- This is an **OPEN BOOK** examination. Answer **all FOUR** questions.
- Clearly state your assumptions.

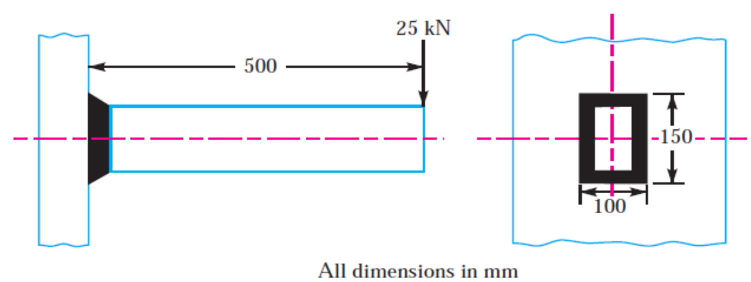
Q1. (a) Two shafts are connected by means of a flange coupling to transmit torque of 25 N-m. The flanges of the coupling are fastened by four bolts of the same material at a radius of 30 mm. Find the size of the bolts if the allowable shear stress for the bolt material is 30 MPa. (Refer Annex)

(b) A lever loaded safety valve has a diameter of 100 mm and the blow off pressure is 1.6 N/mm2. The fulcrum of the lever is screwed into the cast iron body of the cover. Find the diameter of the threaded part of the fulcrum if the permissible tensile stress is limited to 50 MPa and the leverage ratio is 8.(Refer Annex) (25 marks)

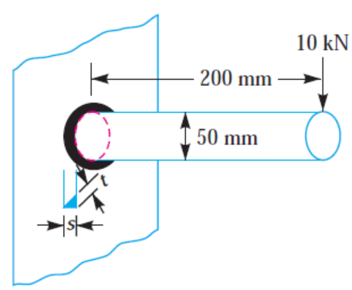
Q2. (a) A particular machine part is subjected in service to a maximum load of 10 kN. With the thought of providing a safety factor of 1.5, it is designed to withstand a load of 15 kN. If the maximum load encountered in various applications is normally distributed with a standard deviation of 2 kN, and if part strength is normally distributed with a standard deviation of 1.5 kN, what failure percentage would be expected in service?(Refer Annex)

(b) A shaft is subjected to a maximum load of 10 kN. It is designed to withstand a load of 15 kN. If the maximum load encountered is normally distributed with a standard deviation of 2.5 kN, and if shaft strength is normally distributed with a standard deviation of 2.0 kN, what failure percentage would be expected?(Refer Annex) (25 marks)

Q3. (a) A rectangular cross-section bar is welded to a support by means of fillet welds as shown in the Figure 1a. Determine the size of the welds, if the permissible shear stress in the weld is limited to 75 MPa.



(a) Q3 (a)



(b) Q3(b)

(b) A 50 mm diameter solid shaft is welded to a flat plate as shown in the Figure 1b. If the size of the weld is 15 mm, find the maximum normal and shear stress in the weld.

(20 marks)

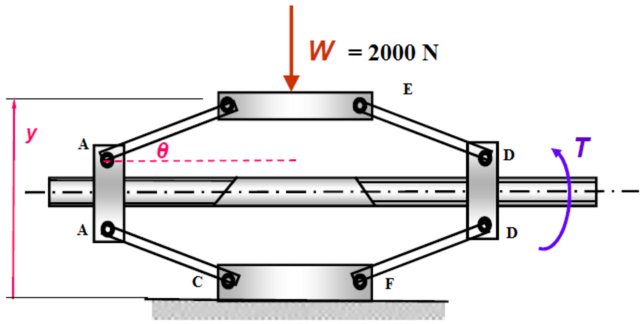


Figure 2: Scissors jack

Q4. The left half of the operating spindle of a lifting jack/scissors jack that is shown in the Figure 2 given below is threaded and is inserted through a nut to which the side links **AB** and **AC** are hinged ar point **A**. The screw has a single start square thread with an outer diameter of 14.0 mm and pitch of 4.0 mm. The right end of the operating spindle is inserted through a bush to which the side links **DE** and **DF** are hinged at point **D**. The bush rests against a collar attached to the shaft. The thrust bearing between the bush and the collar has a mean diameter of 22.0 mm. The lower plate of the jack rests on the ground and it is used to life a load of 2000 N, which acts on the upper plate. The coefficient of friction at the screw as well as at the thrust bearing is 0.13. All your four links are inclined to the horizontal by 35 degrees. i.e. $\theta = 35°$. **AB=AC=DE=DF**

1. **Determine the torque** which should be exerted on the operating spindle in order to lift the load, and
2. **Shear stress** in the most heavily loaded thread in the screw

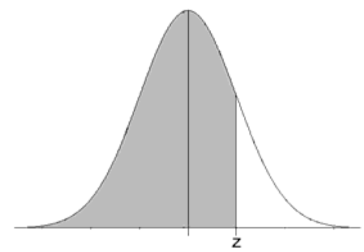
You may assume that the most heavily loaded thread carries one third of the total axial load on the screw.
You may assume following results where standard notation has been used.
Friction torque at a thrust bearing $= \mu W r_m$ where $\mu =$ coefficient of friction at the bearing.
W = Thrust force carried by the bearing and $r_m =$ mean radius of the thrust bearing.
Torque which should be exerted on a screw in order to lift a load $= \frac{W D_m}{2} \times \tan[\lambda + \alpha]$

where **W** = load carried by the screw, $D_m =$ mean diameter of the screw,

$\lambda =$ friction angle at the thread and $\alpha =$ helix angle of the thread (30 marks)

End of the Question Paper

Standard Normal Cumulative Probability Table



Cumulative probabilities for POSITIVE z-values are shown in the following table:

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990
3.1	0.9990	0.9991	0.9991	0.9991	0.9992	0.9992	0.9992	0.9992	0.9993	0.9993
3.2	0.9993	0.9993	0.9994	0.9994	0.9994	0.9994	0.9994	0.9995	0.9995	0.9995
3.3	0.9995	0.9995	0.9995	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996	0.9997
3.4	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9998

Standard Dimensions of Screw Threads

Designation	Pitch (mm)	Major or nominal dia: $(d = D)$	Pitch dia: (d_p) mm	Minor or core (d_c) mm Bolt	Nut	Depth of thread (bolt) mm	Stress Area mm^2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
M 7	1	7.000	6.350	5.773	5.918	0.613	28.9
M 8	1.25	8.000	7.188	6.466	6.647	0.767	36.6
M 10	1.5	10.000	9.026	8.160	8.876	0.920	58.3
M 12	1.75	12.000	10.863	9.858	10.106	1.074	84.0
M 14	2	14.000	12.701	11.546	11.835	1.227	115
M 16	2	16.000	14.701	13.546	13.835	1.227	157
M 18	2.5	18.000	16.376	14.933	15.294	1.534	192
M 20	2.5	20.000	18.376	16.933	17.294	1.534	245
M 22	2.5	22.000	20.376	18.933	19.294	1.534	303
M 24	3	24.000	22.051	20.320	20.752	1.840	353
M 27	3	27.000	25.051	23.320	23.752	1.840	459
M 30	3.5	30.000	27.727	25.706	26.211	2.147	561
M 33	3.5	33.000	30.727	28.706	29.211	2.147	694
M 36	4	36.000	33.402	31.093	31.670	2.454	817
M 39	4	39.000	36.402	34.093	34.670	2.454	976
M 42	4.5	42.000	39.077	36.416	37.129	2.760	1104
M 45	4.5	45.000	42.077	39.416	40.129	2.760	1300
M 48	5	48.000	44.752	41.795	42.587	3.067	1465
M 52	5	52.000	48.752	45.795	46.587	3.067	1755
M 56	5.5	56.000	52.428	49.177	50.046	3.067	2022
M 60	5.5	60.000	56.428	53.177	54.046	3.374	2360
Fine series							
M 8 × 1	1	8.000	7.350	6.773	6.918	0.613	39.2
M 10 × 1.25	1.25	10.000	9.188	8.466	8.647	0.767	61.6
M 12 × 1.25	1.25	12.000	11.184	10.466	10.647	0.767	92.1
M 14 × 1.5	1.5	14.000	13.026	12.160	12.376	0.920	125
M 16 × 1.5	1.5	16.000	15.026	14.160	14.376	0.920	167
M 18 × 1.5	1.5	18.000	17.026	16.160	16.376	0.920	216
M 20 × 1.5	1.5	20.000	19.026	18.160	18.376	0.920	272
M 22 × 1.5	1.5	22.000	21.026	20.160	20.376	0.920	333
M 24 × 2	2	24.000	22.701	21.546	21.835	1.227	384
M 27 × 2	2	27.000	25.701	24.546	24.835	1.227	496
M 30 × 2	2	30.000	28.701	27.546	27.835	1.227	621
M 33 × 2	2	33.000	31.701	30.546	30.835	1.227	761
M 36 × 3	3	36.000	34.051	32.319	32.752	1.840	865
M 39 × 3	3	39.000	37.051	35.319	35.752	1.840	1028

Note : In case the table is not available, then the core diameter (d_c) may be taken as 0.84 d, where d is the major diameter.