

- a. 48.6 mm b. 58.7 mm.
c. 68.5 mm. d. 39.5 mm.

ANSWER: B

2. A 2-in. diameter solid shaft has a maximum bending moment of 6000 lb-in. and an applied torque of 3000 lb-in. Compute the equivalent bending moment.

- a. 6555 lb-in. b. 6755 lb-in.
c. 6355 lb-in. d. 6500 lb-in.

ANSWER: C

3. A solid circular shaft is used to transmit 200 hp at 1000 rpm. What shaft diameter is required if the allowable maximum shearing stress is 20,000 psi?

- a. 1.475 in. b. 1.250 in.
c. 1.750 in. d. 2.000 in.

ANSWER: A

4. In problem No.3, if a hollow shaft is used having an inside diameter equal to the diameter of the solid shaft, determine what must be the outside diameter of this shaft if the angular twist of the hollow and solid shafts is to be equal.

- a. 1.475 in. b. 1.402 in.
c. 1.755 in.* d. 1.250 in.

ANSWER: C

5. A solid cylindrical shaft, 5.08 cm in diameter, 45.72 cm long, is used for the transmission of mechanical power at a rate of 33.57 KW running at 1500 rpm. The modulus of rigidity for the material used is 96.5 GPa. Calculate the torsional deflection of the shaft in degrees.

- a. 0.93° b. 0.075°
c. 0.06° d. 0.083°

ANSWER: D

6. A solid transmission shaft is 3.5 inches in diameter. It is desired to replace it with a hollow shaft of the same material and same torsional strength but its weight should only be half as much as the solid shaft. Find the inside diameter of the hollow shaft in millimeters.

- a. 86.97 b. 84.60
c. 65.97 d. 54.30

ANSWER: A

7. A 76 mm solid shaft is to be replaced with a hollow shaft of equal torsional strength. Find the percentage of weight saved, if the outside diameter of the hollow shaft is 100 mm.

- a. 56.53% b. 67.31%
c. 48.49% d. 72.50%

ANSWER: A

8. A centrifugal pump is directly coupled to a motor. The pump rating is 3,600 liters per minute against a total head of 8 meters of water. Pump efficiency is 65% at shaft speed of 550 rpm. Calculate the torsional stress induced in the 40-mm diameter motor shaft.

- a. 11,193.45 KPa b. 12,429.72 KPa
c. 10,010.85 KPa d. 13,113.83 KPa

ANSWER: C

BOLTS AND SCREWS

1. What is the frictional HP acting on a collar loaded with 100 kg weight? The collar has an outside diameter of 100 mm and an internal diameter of 40 mm. The collar rotates at 1000 rpm and the coefficient of friction between the collar and the pivot surface is 0.15.

- a. 0.8 HP b. 0.5 HP
c. 0.3 HP d. 1.3 HP

ANSWER: A

2. What is the working strength of a 2" bolt which is screwed up tightly in a packed joint when the allowable working stress is 12,000 psi?

- a. 20,120 lbs b. 25,347 lbs
c. 20,443 lbs d. 20,200 lbs

ANSWER: B

3. A single square thread power screw is to raise a load of 70 KN. The screw has a major diameter of 36 mm and a pitch of 6 mm. The coefficient of thread friction and collar friction are 0.13 and 0.10 respectively. If the collar mean diameter is 90 mm and the screw turns at 60 rpm, find the combined efficiency of the screw and collar.

- a. 13.438% b. 14.256%
c. 15.530% d. 12.526%

ANSWER: D

4. The manhole cover of an ammonia storage tank is to be held by 24 stud bolts. If the pressure inside the tank will remain constant at 12.5 kg per sq. cm., and the manhole diameter is 508 mm., what

would be the size of the bolts if the load will be carried by the bolts? Disregard elastic limit of material.

- a. 24.5 mm b. 26.1 mm.
c. 25.4 mm d. 28.7 mm.

ANSWER: C

SPRINGS

1. A helical spring having squared and ground ends has a total of 18 coils and the material has a modulus of elasticity in shear of 78.91 GPa. If the spring has an outside diameter of 10.42 cm., and a wire diameter of 0.625 cm., compute the maximum deflection that can be produced in the spring due to a load of 50 kgs.

- a. 302 mm b. 342 mm
c. 551 mm d. 515 mm

ANSWER: C

2. A coiled spring with 1 ¾ -in. outside diameter is required to work under load of 140 lbs. Wire diameter used is 0.192 in., spring is to have seven active coils, and the ends are to be closed and ground. Determine the unit deflection when under the load. Assume modulus of rigidity equal to 12 million psi and mean radius to be 0.779 in.

- a. 1 in. b. 1.225 in.
c. 1.817 in. d. 3.518 in.

ANSWER: C

3. A safety valve spring having 9 ½ coils has the ends squared and ground. The outside diameter of the coil is 115 mm and the wire diameter is 13 mm. it has a free length of 203 mm. Determine the length of the wire to which this spring must be initially compressed to hold boiler pressure of 1.38 MPa on the seat of 32 mm diameter. Modulus of rigidity is taken as 80 GPa.

- a. 172 mm b. 158 mm
c. 192 mm d. 179 mm

ANSWER: A

4. The smaller of two concentric helical springs is made of 22 mm-diameter steel spring and has an outside diameter of 100 mm with 10 active coils. The outer spring is made of 32 mm-diameter steel spring and has an outside diameter of 250 mm with 8 active coils. Before the load is applied, the outer spring is 25 mm longer than the inner spring. If the load of 90 KN is applied to this nest of springs, find the spring rate of each spring in KN/m..

- a. 507.5, 143.6 b. 731.5, 212.5
c. 493.8, 126.5 d. 976.1, 318.8

ANSWER: C

KEYS

1. A rectangular key was used in a pulley connected to a line shaft with a power of 7.46 KW at a speed of 1200 rpm. If the shearing stress of the shaft and key are 30 N/mm² and 240 N/mm² respectively, what is the length of the rectangular key if the width is one-fourth that of the shaft diameter?

- a. 26.60 mm
- b. 31.24 mm
- c. 41.55 mm
- d. 25.92 mm

ANSWER: D

2. A 76.2 mm diameter shafting of SAE 1040 grade, cold-rolled, has a yield point of 50 ksi and with a $\frac{3}{4} \times \frac{3}{4} \times 5$ inches key. Compute the minimum yield point in the key in order to transmit the torque of the shaft. The factor of safety to use is 2 and $S_{YS} = 0.5 S_y$.

- a. 39.12 ksi
- b. 42.13 ksi
- c. 27.92 ksi
- d. 47.12 ksi

ANSWER: D

3. Determine the shear force acting on the key for a 4-in. diameter shaft transmitting 1000 hp at 1000 rpm. The allowable shear stress in the key is 15,000 psi and the allowable compressive stress is 30,000 psi.

- a. 64,000 lb-in
- b. 65,000 lb-in
- c. 63,000 lb-in
- d. 70,000 lb-in

ANSWER: C

COUPLINGS

1. A flanged bolt coupling has ten 25.4 mm diameter bolts evenly tightened around a 415 mm bolt circle. Determine the torque capacity of the connection if the allowable shearing stress in the bolt is 50 MPa.

- a. 59.95 KN-m
- b. 52.60 KN-m
- c. 46.15 KN-m
- d. 43.8 KN-m

ANSWER: B

2. A flange coupling has an outside diameter of 200 mm and connects two 40-mm shafts. There are four 16 mm bolts on a 140-mm bolt circle. The radial flange thickness is 20 mm. If the torsional stress in the shaft is not to exceed 26 MPa, determine the shearing stress in the bolts if uniformly distributed/

- a. 8.5 N/mm²
- b. 5.8 N/mm²
- c. 6.5 N/mm²
- d. 7.5 N/mm²

ANSWER: B

3. Two short shafts having identical diameters of 38.1 mm and rotating at 400 rpm are connected by a flange coupling having four bolts with a 100 mm bolt circle. The design shearing stress of the bolt is 12 N/mm² and design compressive stress of the flange is 15 N/mm². How thick should the flange be in mm.?

- a. 11.51 mm
- b. 13.60 mm
- c. 12.49 mm
- d. 15.65 mm

ANSWER: A

4. A flange coupling is to be designed, using 25-mm diameter bolts, at a distance of 152 mm from the center of the shaft. Allowable shearing stress on the bolts is 103 MPa. If the shaft is to transmit 5800 HP at a speed of 1,200 rpm, how many bolts are needed in the connection?

- a. 2.
- b. 3
- c. 4
- d. 5

ANSWER: D

FLYWHEELS

1. A flywheel rotating at 120 rpm is slowed down to 102 rpm during a punching operation that requires $\frac{3}{4}$ second for the punching portion of the cycle. What angular deceleration does the flywheel experience in radians per sec per sec?

- a. -2.52
- b. -2.25
- c. 2.52
- d. 2.25

ANSWER: A

2. A flywheel has a diameter of 1.5 m, and a mass of 800 kgs. What torque, in N-m, is needed to produce an angular acceleration of 100 revolutions per minute, per second?

- a. 225
- b. 974
- c. 1158
- d. 2356

ANSWER: D

3. A cast-iron flywheel with a mean diameter of 36 inches changes speed from 300 rpm to 280 rpm while it gives up 8000 ft-lb of energy. What is the weight of the rim?

- a. 1635.57 lbs
- b. 1209.62 lbs
- c. 1556.57 lbs
- d. 1597.57 lbs

ANSWER: A

4. Find the rim thickness for a cast iron flywheel with a width of 200 mm, a mean diameter of 1.2 m, a normal operating speed of 300 rpm, a coefficient of fluctuation of 0.05 and which is capable of handling 3000 N-m of kinetic energy. Assume that the hub and

arms represent 10% of the rim weight and the specific weight of cast iron is 7208 kg/m³.

- a. 25.28 mm
- b. 28.82 mm
- c. 28.25 mm
- d. 25.25 mm

ANSWER: C

5. What would be the weight of the flywheel in kg, if the weight of the rim is 3 times the sum of the weight of the hub and arms? Given the outside diameter and inside diameter to be 24 in and 18 in respectively and the rim width is 4.5 in. (Assume steel flywheel).

- a. 142.95
- b. 162.95
- c. 202.95
- d. 152.95

ANSWER: D

6. A shearing machine requires 150 kg-m of energy to shear a steel sheet, and has a normal speed of 3 rev/sec, slowing down to 2.8 rev/sec during the shearing process. The flywheel has a mean diameter of 75 cm and weighs 0.018 kg/cm³. The width of the rim is 30 cm. If the hub and arms of the flywheel account for 15% of the total weight, find the thickness of the rim.

- a. 1 cm
- b. 5 cm
- c. 4 cm
- d. 3 cm

ANSWER: D

7. Find the weight of the flywheel needed by a machine to punch 20.5 mm holes in 15.87 mm thick steel plate. The machine is to make 30 strokes per minute and a hole must be punched every stroke. The hole is to be formed during 30° rotation of the puncher's crankshaft. A gear train with a ratio of 12:1 is to connect the flywheel shaft to the crankshaft. Let the mean diameter of the flywheel rim be 91.44 cm. The minimum flywheel speed is to be 90% of the maximum and assume mechanical efficiency of the machine to be 80%.

- a. 68 kg.
- b. 96 kg.
- c. 90 kg.
- d. 82 kg.

ANSWER: B

BEARINGS

1. A journal bearing with a diameter of 2.25 in is subjected to a load of 1000 lbs. while rotating at 200 rpm. If the coefficient of friction is taken as 0.02 and L/D is 3.0, find the total work of friction in ft-lb per min.

- a. 15.19
- b. 6.750
- c. 1958
- d. 2356

ANSWER: D

- a. 59.49 b. 40.72
c. 38.78 d. 37.80

ANSWER: B

CLUTCHES

1. A disc clutch having an outside diameter of 32 cm and an inside diameter of 12.7 cm. is connected to an engine that turns at 750 rpm. The coefficient of friction is 0.6 while the pressure between the friction surfaces is 2 kg/cm². Compute the force on the clutch pedal necessary to disengage the clutch disc from the engine.

- a. 1355.14 kg. b. 2524,21 kg.
c. 3248.41 kg. d. 2621.67 kg.

ANSWER: A

2. In problem no. 1, compute the power transmitted by the engine.

- a. 70.49 KW b. 58.38 KW
c. 69.30 KW d. 68.38 KW

ANSWER: D

3. A local utility vehicle production company has considered to use in one of the designs a multi-disc clutch consisting of 9 steel discs and 8 bronze discs, with effective outside and inside diameter of 220 mm and 160 mm respectively. If the shaft turns at 1500 rpm and an axial force of 600 N is applied, find the horsepower capacity, considering a coefficient of friction of 0.25

- a. 48.41 hp b. 47.59 hp
c. 52.48 hp d. 50.40 hp

ANSWER: A

4. An engine of a motor vehicle with a wheel diameter of 712 mm develops 50 KW at 2000 rpm. The combined efficiency of the differential and transmission is 75% with an over-all speed reduction of 25 is to 1. Determine the draw bar pull developed in KN.

- a. 13.40 b. 15.45
c. 14.55 d. 12.57

ANSWER: D

5. In problem no.4, determine the axial force on the clutch in KN. Outside and inside diameter of the clutch are 300 mm and 240 mm respectively. There are two pairs of mating surfaces with a coefficient of friction of 0.3 (Use uniform wear method).

- a. 4.392 b. 5.367
c. 2.951 d. 2.493

ANSWER: C

6. A cone clutch has an angle of 10° and a coefficient of friction of 0.42. Find the axial force required if the capacity of the clutch is 7.46 KW at 500 rpm. The mean diameter if the active conical section is 300 mm.

- a. 0.4022 KN b. 0.3928 KN
c. 0.2453 KN d. 0.2384 KN

ANSWER: A

7. How much torque can a cone clutch transmit if the angle of the conical elements is 10 deg., the mean diameter of the conical clutch sections is 203 mm, and an axial force of 556 N is applied? Assume coefficient of friction of 0.45 between the clutch elements.

- a. 146.24 N-m b. 213.43 N-m
c. 148.35 N-m d. 232.26 N-m

ANSWER: A

BRAKES

1. A simple band brake has a 76 cm drum and fitted with a steel band 2/5 cm. thick lined with a brake lining having a coefficient of friction of 0.25. The arc of contact is 245°. The drum is attached to a 60-cm. hoisting drum that sustains a rope load of 820 kg. The operating force has a moment arm of 1.50 m., and the band is attached 12 cm from the pivot point. Find a torque just required to support the load (clockwise).

- a. 2413.26 N-m b. 3492.31 N-m
c. 2453.29 N-m d. 1894.82 N-m

ANSWER: A

2. In problem no. 1, find what force F is required if the direction of rotation is reversed.

- a. 679.5 N b. 659.5 N
c. 783.7 N d. 773.8 N

ANSWER: D

3. In problem no. 1, find the width of a steel band for a tensile stress of 50 MPa.

- a. 52.4 mm b. 43.9 mm
c. 48.4 mm d. 67.7 mm

ANSWER: C

MISCELLANEOUS PROBLEMS

Problems 1-5. A marine turbine is developing 15,000 hp and it turns the shaft at 300 rpm. The propeller which is attached to the shaft develops a thrust of 150,000 lbs. A hollow steel shaft with an outside diameter of 14 in. will be used.

1. Compute for the torque.

- a. 622,000 ft-lb b. 826,000 ft-lb
c. 486,600 ft-lb d. 262,600 ft-lb

ANSWER: D

2. Determine the inside diameter of the shaft if the maximum shearing stress based on torsion alone is not to exceed 7,500 psi.

- a. 5.95 in. b. 3.5 in. c. 2.95 in.
d. 9.59 in.

ANSWER: D

3. What would be the propeller's thrust that is developed in kilograms?

- a. 68,180 kgs. b. 26,180 kgs.
c. 86,880 kgs. d. 186,000 kgs.

ANSWER: A

4. What is the diameter of the solid shaft?

- a. 1.88 in. b. 12.886 in. c. 6.128 in.
d. 8.621 in.

ANSWER: B

5. What percentage savings in weight over a solid shaft is effected?

- a. 92.3% b. 73.3%
c. 37.3% d. 67.3%

ANSWER: C

Problems 6-10. The yield strength of a structural steel member is 36,000 psi. The tensile stress is 8,240 psi.

6. What is the equivalent of the yield strength in MPa?

- a. 150 Mpa b. 350 MPa
c. 100 MPa d. 250 MPa

ANSWER: D

7. The tensile stress can be expressed as:

- a. 83 Mpa b. 38 MPa
c. 57 MPa d. 75 MPa

ANSWER: C

8. The factor of safety in tension (English system) will be:
- a. 7.43
 - b. 4.95
 - c. 3.47
 - d. 4.37

ANSWER: C

9. What is the computed safety factor of tension using S.I. system of calculation?
- a. 3.49
 - b. 4.39
 - c. 4.95
 - d. 9.39

ANSWER: B

10. If the tensile stress is only 7,200 psi, what will be the new factor of safety?
- a. 8
 - b. 10
 - c. 5
 - d. 7

ANSWER: C

Problems 11-13. A solid steel machine shaft with a safe shearing stress of 7000 psi transmits a torque of 10,500 in-lb. A square key is used whose width is equal to one-fourth the shaft diameter and whose length is equal to 1 ½ times the shaft diameter.

11. Find key dimensions.
- a. ½ in and 3 in
 - b. ½ and 2.5 in
 - c. ¾ in and 2.5 in
 - d. ¾ in and 3 in

ANSWER: A

12. Determine the crushing stress of the key.
- a. 7000 psi
 - b. 9,000 psi
 - c. 14,000 psi
 - d. 17,000 psi

ANSWER: C

13. Obtain the factor of safety of the key in crushing, allowing an ultimate shearing stress of 50,000 psi and ultimate stress for compression of 60,000 psi.
- a. 2.5
 - b. 3.4
 - c. 7.4
 - d. 4.3

ANSWER: D

Problems 14-16. Design a pair of spur gears for a motor drive as follows: motor delivers 50 hp at 1,200 rpm; gear reduction, 6:1. Assume pinion pitch diameter to be 5 in.; number of teeth, 15; diametral pitch, 3.

14. Indicate the pitch diameter, number of teeth and speed of the mating spur gear.
- a. 30-in, 90 teeth, 200 rpm
 - b. 20-in, 80 teeth, 150 rpm
 - c. 90-in, 30 teeth, 200 rpm
 - d. 90-in, 30 teeth, 150 rpm

ANSWER: A

15. What is the velocity of the driven gear in fpm?
- a. 1570
 - b. 200
 - c. 1200
 - d. 1500

ANSWER: A

16. Find the tooth load
- a. 1050 lb
 - b. 1570 lb
 - c. 2050 lb
 - d. 2890 lb

ANSWER: A

Problems 17-20. A storage tank for air, 36 inches in diameter, is to withstand an internal pressure of 200 psi with a design factor of 4 based on S_u . The steel has the strength equivalent of C1020 annealed and the welded joints should have a relative strength of 90%.

17. If S_u for annealed C1020 steel is 57 ksi, compute for S_t .
- a. 25,400 psi
 - b. 42,510 psi
 - c. 52,400 psi
 - d. 14,250 psi

ANSWER: D

18. Determine a suitable plate thickness.
- a. 7/64 in.
 - b. 9/32 in.
 - c. 5/32 in.
 - d. 3/64 in.

ANSWER: B

19. Compute the stress in a diametral section.
- a. 2,400 psi
 - b. 3,240 psi
 - c. 6,400 psi
 - d. 1,640 psi

ANSWER: C

20. If a Japanese engineer would ask you, how many centimeters is the minimum plate thickness required?
- a. 0.75 cm.
 - b. 0.27 cm
 - c. 0.17 cm
 - d. 0.15 cm.

ANSWER: A

Problems 21-24. An 8-in long steel has a cross-sectional area of 0.25 in². After a load of 5,000 lbs has been applied, the length is found to be 8.0065 in.

21. Find the unit stress.
- a. 40,000 psi
 - b. 60,000 psi
 - c. 20,000 psi
 - d. 80,000 psi

ANSWER: C

22. What is the unit deformation induced?
- a. 0.00081
 - b. 0.4100
 - c. 0.00041
 - d. 0.8100

ANSWER: A

23. What is the modulus of elasticity?
- a. 24,690,000 psi
 - b. 69,240,000 psi
 - c. 54,960,000 psi
 - d. 46,920,000 psi

ANSWER: A

24. What would be the new modulus of elasticity for the applied load of 5,000 kgs.?
- a. 21,300,000 psi
 - b. 24,000,000 psi
 - c. 32,140,000 psi
 - d. 54,357,000 psi

ANSWER: D

Problems 25-28. A 15/16-in wide key has a depth of 5/8 in. It is 12 inches long and is to be used on a 200 hp, 1160 rpm, squirrel-cage induction motor. The shaft diameter is 3 7/8 inches. The maximum running torque is 200% of the full-load torque.

25. Compute the maximum torque.
- a. 17,330 in-lb
 - b. 21,733 in-lb
 - c. 37,210 in-lb
 - d. 733,211 in-lb

ANSWER: B

26. Compute for F.
- a. 11,217 lbs
 - b. 57,211 lbs
 - c. 27,111 lbs
 - d. 72,101 lbs

ANSWER: A

27. Determine the maximum shearing stress on the key.
- a. 779 psi
 - b. 997 psi
 - c. 197 psi
 - d. 279 psi

ANSWER: D

28. Determine the maximum compressive stress on the key.

- a. 5990 psi
- b. 2990 psi
- c. 7290 psi
- d. 9920 psi

ANSWER: B

29. The rpm of a milling cutter is 200; feed is 0.02 mm per tooth. If the feed per minute is 200 mm, calculate the number of teeth in the cutter.

- a. 45
- b. 60
- c. 80
- d. 50

ANSWER: D

30. How long will it take to saw a rectangular piece of aluminum alloy plate 6 in. wide and 2 in. thick if the length of cut is 6 in.? The power hacksaw makes 120 strokes/min, and the average feed per stroke is 0.0040 in.

- a. 12.5 min.
- b. 13.3 min.
- c. 15 min.
- d. 16.5 min.

ANSWER: A