IBONG TIRIRIT (MDSP 3)

MACHINE DESIGN/SHOP PRACTICE (Solved Problems and Answered Elements)

MULTIPLE CHOICE QUESTIONS
Select the best answer from each of the following questions. On the answer sheet provided, shade the box that corresponds to your choice. Strictly no erasures allowed

1. 900 kg of load is to be raised using a double threaded ACME screw driven by a motor at 400rpm. The load is to be raised at a speed of 10 m/min. The screw has a pitch diameter of 36 mm; the coefficient of friction on threads is 0.15. The friction torque on the thrust bearing of the motor is taken as 20 % of the total input. Determine the lead angle.
a) 12.465º b) 14.265º c) 15.462º d) 16.452º

Solution: For the lead, $L = \frac{V}{n} = \frac{10}{400} = 0.025\ \text{m} = 25\ \text{mm}$

For the lead angle, $\lambda = \tan^{-1}\left(\frac{L}{\pi D_m}\right) = \tan^{-1}\left(\frac{25}{36\pi}\right) = 12.465^{o}$

2. A 500 mm brake drum has a simple brake that is to absorb a torque of 250 N-m. If the coefficient of friction and the contact angle between the band and drum are 0.2 and 180º, respectively, and that the length of the brake arm is twice the drum diameter, determine the minimum braking force applied at the free end of the brake arm.
a) 721.5 N b) 752.1 N c) 275.1 N d) **572.1 N**

Solution: $\frac{F_1}{F_2} = e^{f\theta} = 1.874: \rightarrow F_{b\min} = \frac{F_2(a)}{L}: a = D: \rightarrow L = 2D \rightarrow F_{b\min} = \frac{F_2}{2} = \frac{\frac{2T}{D}}{2(1.874-1)} = 572.1\text{N}$

3. In a simply-supported shaft of 2-ft span of 2-in. diameter, the allowable flexural stress is 6,000 psi. Determine the maximum permissible concentrated bending load that it may be carried.
a) 854.7 lb b) 485.7 lb c) 587.4 lb d) **785.4 lb**

Solution: Bending moment is maximum if F is applied at mid span.

$$\sigma = \frac{Mc}{I} = \frac{32M}{\pi D^3} \rightarrow M = \frac{FL}{4} \rightarrow \frac{32(F)(24)}{4\pi(2^3)} = 6000 \rightarrow F = 785.4\text{lb.}$$

4. A tensile load of 8 tons is transmitted to a bar of rectangular section is made of AISI C1020 steel (Su = 65,000 psi). If the width of the bar is 1.5 times the thickness, find the bar dimensions if the factor of utilization is 0.25 based upon the ultimate strength.
a) 0.5" x 0.75" b) 1" x 1.5" c) 1.5" x 2.25" d) **0.81" x 1.22"**

Solution: $\text{Factor of Utilization} = \frac{1}{\text{Factor of Safety}}$ $s = \frac{F}{1.5b^2} = \frac{S_u}{N} = (\text{U.F x } S_u): \frac{8\text{ x }2000}{1.5b^2} = 0.25\text{x}65000: \rightarrow b = 0.81\text{ in.}$

and b x h = 0.81" x 1.22"

5. A connecting rod is to form from a low carbon steel sheet 3/8 in. thick, lined with aluminum 1/8 in. thick. Steel has a modulus of elasticity of 30 x 10^6 psi, while aluminum of 10.3 x 10^6 psi. If the aluminum has a tensile stress of 10,000 psi, what is the corresponding stress of the steel sheet?
a) 12,961 psi b) 96,122 psi c) **29,126 psi** d) 26,191 psi

Solution: $\sigma = E\,\varepsilon$: With constant strain ε, $\sigma_{AL}/E_{AL} = \sigma_{ST}/E_{ST}$. Thus, σ_{ST} = (30/10.3) x (10,000) = 29,126 psi.

6. A 1.5 m long, 9 cm square bar is to be held firmly at one end and to support a load of 2000 kg at the other end. The bar is to be made from steel with yield strength of 500 MPa. What factor of safety is used in the design if the stress concentration factor is 1.3?
a) 2.34 b) 3.45 c) 2.67 d) **1.59**

Solution: $\frac{S_Y}{N} = \frac{K_t Mc}{I}$ Where, $M = FL = 29\,430\,000\ \text{N}\cdot\text{mm}$ $I = \frac{a^4}{12} = 5\,467\,500\,\text{mm}^4$ $c = a/2 = 45\ \text{mm}$

then $N = \frac{S_y I}{K_t Mc}$ thus: $N = 1.59$

7. 222.449 kN of tensile load is applied to a round bar made from SAE 1025 low carbon steel. Using a factor of safety of 4 and assuming that the stress concentration factor is 1.45, what is the required outside diameter in mm of the member if the ratio of the inside and outside diameter is 0.75? For the material, the yield strength is 276 MPa.
a) 283.34 b) **116.64** c) 98.76 d) 156.54

Solution: $\frac{S_y}{N} = \frac{K_t F}{A} = \frac{4K_t F}{\pi\left(D_O{}^2 - D_i{}^2\right)} = \frac{4K_t F}{\pi D_O{}^2\left(1 - \frac{D_i{}^2}{D_o{}^2}\right)}$ thus: $D_o = 116.64 \text{ mm}$

8. An abrupt brake locked that the car begins to skid when it is traveling at 96.6 kph. If it takes 2 seconds to slow down the car to 4.83 kph, how far in meters will it have traveled before it car comes to a stop?
a) **53.64** b) 276 c) 137 d) 876

Solution: Velocities, in m/s, $V_i = 96.6 \text{ kph} = 26.83 \text{ m/s}$ $V_f = 48.3 \text{ kph} = 13.42 \text{ m/s}$

Acceleration, $a = \frac{V_f - V_i}{t} = \frac{13.42 - 26.83}{2} = -6.71 \text{ m/s}^2$ Distance, $s = \frac{V_f{}^2 - V_i{}^2}{2a} = \frac{0 - (26.83)^2}{2(-6.7)} = 53.64 \text{ m}$

9. What is the weight of a 2 steel plates sized ¾" x 3" x 20 ft?
a) 1836 lb **b) 3667 lb** c) 1698 lb d) 1848 lb

Solution: Density or specific weight of a steel plate = 0.283 lb/ft^3

$$W = \gamma V = (0.283 \text{ lb/in}^3)(0.75 \text{ in.})(3)(12 \text{ in})(20)(12 \text{ in})(2) = 3667.68 \text{ lb}$$

10. Determine the load required, in kN, to be applied to a 25 mm round steel bar 2.5 m long (E = 207 GPa) to stretch the bar 1.3 mm.
a) 52.84 b) 60 c) 53.048 d) 42.562

Solution: $F = \frac{A E}{L}\delta = \frac{\left(\frac{\pi}{4}D^2\right)E}{L}\delta = \frac{\left(\frac{\pi}{4}\right)(25)^2 (207\,000)(1.3)}{2\,500} = 52\,837.66 \text{ N} = 52.84 \text{ kN}$

11. A bus is travelling at 90 kph when the brakes are applied. If it travels a distance of 60 meters before coming to a stop, what is its acceleration m/s^2?
a) – 7.08 b) 6.36 **c) – 5.21** d) 5.76

Solution: $V_1 = (90 \text{ kph})(1000 \text{ m/km})\left(\frac{1 \text{ hr}}{3600 \text{ s}}\right) = 25 \text{ m/s}$ $a = \frac{V_2^2 - V_1^2}{2S} = \frac{0 - (25)^2}{2(60)} = -5.20 \text{ m/s}^2$

12. Find the torsional deflection, in degrees per foot length, of a steel shaft 1.75 inches in diameter which transmits 40 Hp at 1800 rpm. Assume a modulus of rigidity of 12 x 10^6 psi.
a) 0.0871 b) 0.00871 c) 0.871 d) 0.000871

Solution: $\frac{\theta}{L} = \frac{T}{JG} = \frac{32T}{\pi D^4 G} = \frac{32\left(\frac{63000 \text{ Hp}}{n}\right)}{\pi D^4 G} = \frac{32\left[\frac{63000(40)}{1800}\right]}{\pi(1.75)^4(12 \text{ x } 10^6)} = 0.00013 \text{ radian} = 0.0871^o$

13. A spur pinion rotates at 1600 rpm and transmits 50 kW to a mating gear. The pitch diameter of the pinion is 100 mm, and the pressure angle is 20^o. Determine the tangential load, in N.
a) 5 968 b) 5790 c) 5900 d) 5098

Solution: $F_t = \frac{2T}{D} = \frac{2\left(\frac{30P}{\pi n}\right)}{D} = \frac{2\left[\frac{30(50)}{\pi(1600)}\right]}{(0.10)} = 5.968 \text{ kN} = 5\,968 \text{ N}$

14. How much energy, in N-m, does a 450 kg flywheel loss from 180 rpm to 168 rpm? The flywheel has a radius of 375mm.
a) 1472.33 b) 1541.33 **c) 1451.33** d) 1433.51

Solution: $V_1 = 2\pi R N_1 / 60 = 2\pi(0.375)\left(\frac{180}{60}\right) = 7.069 \text{ m/s}$ $V_2 = 2\pi R N_2 / 60 = 2\pi(0.375)\left(\frac{168}{60}\right) = 6.597 \text{ m/s}$

$$\Delta KE = \frac{m\left(V_1^2 - V_2^2\right)}{2} = \frac{450\left[(7.069)^2 - (6.597)^2\right]}{2} = 1451.33 \text{ N}\cdot\text{m}$$

15. A ¾ inch thick steel plate is to punch for a 1-in diameter hole every 10 sec. The actual punching takes 1 sec. The ultimate shear strength of the plate is 60,000 psi. The flywheel of the punch press has a mass moment of inertia of 500 in-lb-sec^2 and rotates at a mean speed of 150 rpm. What is the speed fluctuation, in rpm?
a) 65.4 rpm **b) 64.5 rpm** c) 6.749 rpm d) 67.49 rpm

Solution: $\Delta KE = \left(\frac{1}{2}\right) I\left(\omega_1^2 - \omega_1^2\right) = \left(\frac{1}{2}\right) I\left(\omega_1 - \omega_2\right)\left(\omega_1 + \omega_2\right) = I\left(\omega_1 - \omega_2\right)\left(\frac{\omega_1 + \omega_2}{2}\right) = I\left(\omega_1 - \omega_2\right)\omega$

Mean angular velocity, $\omega = \frac{2\pi N}{60} = \frac{2\pi(150)}{60} = 15.71 \text{ rad/s}$

Punching Force, $F = s_u(\pi dt) = (60\,000)(\pi)(1)(0.75) = 141371.67 \text{ lb}$

Kinetic Energy, $\Delta KE = \frac{1}{2}(F)t = \left(\frac{1}{2}\right)(141\,371.67)\left(\frac{0.75}{12}\right) = 4417.86 \text{ ft}\cdot\text{lb}$

Speed Fluctuation, $(\omega_1 - \omega_2) = \frac{\Delta KE}{I\omega} = \frac{(4417.86 \text{ ft}\cdot\text{lb})(12)}{(500 \text{ in}\cdot\text{lb}\cdot\text{s}^2)(15.71)} = 6.749 \text{ rad/s} = 64.5 \text{ rpm}$

16. An elevator is used to assist the construction of a building. It rises 366 meters with an operating speed of 5 meters per second and reaches full speed in 10.68 meters. When loaded with construction materials, the elevator weighs 2000 kg. Determine the acceleration of the elevator in m/sec^2.
a) 1.17 b) 2.17 c) 3.17 d) 4.17

Solution: $a = \frac{V_2^2 - V_1^2}{2S} = \frac{(5)^2 - (0)^2}{2(10.68)} = 1.17 \text{ m/s}^2$

17. A disc clutch is made of a material with coefficient of friction of 0.4. The shaft speed is 1200 rpm and axial force is 1500 N. The clutch has 6 pairs of contacting friction surfaces with an outside diameter of 200 mm and an inside diameter of 100 mm. Determine the Hp that can be transmitted by the clutch assuming uniform pressure.
a) 35.2 Hp b) 23.5 Hp **c) 47.2 Hp** d) 27.4 Hp

Solution: Friction Radius (Uniform pressure), $r_f = \frac{2}{3}\left(\frac{r_o^3 - r_i^3}{r_o^2 - r_i^2}\right) = \left(\frac{2}{3}\right)\left[\frac{(100)^3 - (50)^3}{(100)^2 - (50)^2}\right] = 77.78 \text{ mm}$

Friction Power or Transmitted Power or Power Capacity,

$$P = \frac{\pi n T_f}{30} = \frac{\pi n}{30}(F_f\ r_f\ n_f) = \frac{\pi n}{30}(f\ F_a\ r_f\ n_f) = \frac{\pi(1200)}{30}(0.4)(1.5)(0.07778)(6)$$ P = 35.19 kW = 47.2 Hp

Where, P = power capacity, kW; F_f = friction force, kN; T_f = torque capacity, kN-m; F_a = axial load, kN; R_f = friction radius or mean radius, m; n_f = no. of pairs of contacting friction surfaces

18. In a butt weld between two plates 0.5 inch thick and 5 inches long, what load may be applied if the allowable working stress for tensile loading is 13000 psi?
a) 32 500 lb b) 25 000 lb c) 44 000 lb d) 50 000 lb

Solution: For butt weld, $P = s_t\ t\ L = (13\,000 \text{ psi})(0.5 \text{ inch})(5 \text{ inches}) = 32\,500 \text{ lb}$

19. 150 N-load is tangentially applied to a 140 mm diameter wheel. If the load is constant, determine the work done, in J, in 12 revolutions of the wheel.
a) 729 J **b) 792 J** c) 972 J d) 927 J

Solution: $W = F\cdot s = (150 \text{ N})(\pi)(0.14 \text{ m})(12) = 791.68 \text{ J}$

20. Determine the force applied tangentially to a bar of screw-jack at a radius of 800 mm if the torque required is 600 N-m.
a) 705 N b) 507 N **c) 750 N** d) 570 N

Solution: $F = \frac{T}{R} = \frac{600}{0.80} = 750\ \text{N}$

21. A 2.54 mm thin hollow sphere is subjected to an internal pressure of 789 kPa. It has a radius of 254 mm. Determine the maximum normal stress on an element of the sphere.
a) 39.45 kPa **b) 39.45 MPa** c) 34.95 kPa d) 34.95 MPa

Solution: $s_L = \frac{pD}{4t} = \frac{(789\,\text{kPa})(2)(0.254\,\text{m})}{4(0.00254)} = 39\,450\ \text{kPa} = 39.45\ \text{MPa}$

22. Determine the hoop stress in a 1.52 m diameter steel pipe that carries water at a pressure head of 168 m. Thickness of the pipe is 9.52 mm.
a) 131.5 MPa b) 135.1 MPa c) 153.1 MPa d) 113.5 MPa

Solution: $s_t = \frac{pD}{2t} = \frac{\rho ghD}{2t} = \frac{(1000)(9.8066)(168)(1.52)}{2(0.00952)(1000)} = 131523.81\,\text{kPa} = 131.524\,\text{MPa}$

23. When loaded with a tensile force, a wire of length 2.5 m has a percentage strain of 0.012 %. Determine the extension of the wire.
a) 0.10 mm b) 0.20 mm **c) 0.30 mm** d) 0.40 mm

Solution: $\delta = \text{Strain x L} = \left(\frac{0.012}{100}\right)(2.5\ \text{m})(1000) = 0.3\ \text{mm}$

24. A 20° involute type spur gear has a diametral pitch of 6. If it has a circular pitch of 0.1309 inch, determine the minimum whole depth of the gear.
a) 0.5593 inch b) 0.5395 inch **c) 0.3595 inch** d) 0.3955 inch

Solution: From Vallance, page 262: $h = \frac{2.157}{p_d} = \frac{2.157}{6} = 0.3595\ \text{inch}$

25. A tempered steel spring is used in a gas engine valve with a mean diameter of 3.81 cm and a wire diameter of 0.635 cm. The maximum load it will have to sustain is 45.15 kg with corresponding deflection of 1.27 cm. Determine the no. of coils to be used. Use modulus of rigidity equal to 80 GPa.
a) 7.4 b) 8.1 **c) 10.4** d) 14.4

Solution: $C = \frac{D_m}{d} = \frac{3.81}{0.635} = 6$ $\quad \delta = \frac{8FC^3n}{Gd}$ $\quad n = \frac{\delta G d}{8FC^3} = \frac{0.0127(80\ \text{x}\ 10^9)(0.00635)}{8(45.15)(9.8066)(6)^3} = 8.43$

Actual Number of coils = n + 2 8.43 + 2 = 10.43

26. Determine the developed acceleration of a roller coaster in m/s^2 when the velocity is 20 m/s at a radius of curvature of 6500 cm.
a) 6.15 m/s^2 b) 6.15 m/s^2 c) 6.51 m/s^2 d) 5.61 m/s^2

Solution: $\text{Weight} = \text{Centrifugal Force}$ $\quad ma = \frac{mV^2}{r}$ $\quad a = \frac{V^2}{r} = \frac{(20)^2}{65} = 6.15\ \text{m/s}^2$

27. A solid shaft is to be used to transmit 75 kW at 550 rpm. If the shaft design stress will not exceed 26 MPa, what is the diameter of the shaft?
a) 63.42 mm b) 42.63 mm c) 36.42 mm d) 64.23 mm

Solution: $T = \frac{30P}{\pi n} = \frac{30(75)}{\pi(550)} = 1.3022\ \text{kN}\cdot\text{m}$ $\quad D = \left(\frac{16T}{\pi s_s}\right)^{\frac{1}{3}} = 63.42\ \text{mm}$

28. Determine the kinetic energy of a 48-inch diameter spoked steel flywheel (γ = 0.28 lb/in^3) having a 12-in wide x 10-in deep rim rotates at 200 rpm. Neglect the weight of its spokes and hub.
a) 84,448 ft-lb b) **68,488 ft-lb** c) 42,248 ft-lb d) 53,123 ft-lb

Solution: $D_m = D_o - t = 48 - 10 = 38$ inches $\quad V = \pi D_m\left(\frac{n}{60}\right) = \pi\left(\frac{38}{12}\right)\left(\frac{200}{60}\right) = 33.16$ fps

$W_f = \gamma V = 0.28(\pi)(38)(12)(10) = 4011.2 \text{lb}$ $\quad KE = \frac{1}{2}\frac{W_f}{g}V^2 = E_{punching} = \left(\frac{1}{2}\right)\left(\frac{4011.2}{32.2}\right)(33.16)^2 = 68488 \text{ ft} \cdot \text{lb}$

29. A square bar is held so that it cannot expand while raising its temperature by 100 °F. Size of the bar is 2 inches on each side. What stress will be induced in it? k = 6.8 x 10^{-6} / °F & E = 30 x 10^6 psi.
a. 17,400 psi b. 18,400 psi c. 19,400 psi **d. 20,400 psi**

Solution: Induced Stress, $s = k E (t_2 - t_1) = (6.8 \text{ x } 10^{-6})(30 \text{ x } 10^6)(100) = 20400 \text{ psi}$

30. Find the moment of inertia, in inches^4, of the rod ¼ inch in diameter and 14 inches long.
a) 1.917 x 10^{-4} b) 1.917 x 10^{-5} c) 3.83 x 10^{-4} d) 3.83 x 10^{-6}

Solution: $I = \frac{\pi D^4}{64} = \frac{\pi(0.25)^4}{64} = 1.917 \text{ x } 10^{-4} \text{ in}^4$

31. A disc clutch having an outside diameter of 32 cm and an inside diameter of 12.7 mm 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/cm^2. Determine the force on the clutch petal necessary to disengage the clutch disc from the engine.
a) 2621.7 kg b) 3248.4 kg c) 2524.2 kg **d) 1355.1 kg**

Solution: $F = pA = p\left[\pi\left(R^2 - r^2\right)\right] = 1355.14 \text{ kg}$

32. A helical gear of 10 inches pitch diameter has a helix angle of 30°, and there are 30 teeth. Find the value of the normal circular pitch.
a) 0.9069 inch/tooth b) 0.6909 inch/tooth c) 0.6096 inch/tooth d) 0.9906 inch/tooth

Solution: $P_c = \frac{\pi D}{T} = \frac{\pi(10)}{30} = 1.0472 \text{ inches/tooth}$ $\quad P_{cn} = P_c \cos\psi = 1.0472(\cos 30^o) = 0.9069 \text{ inch/tooth}$

33. A parallel helical gear set was a 17-tooth pinion driving a 34-tooth gear. The pinion has a right-hand helix angle of 30°, a normal pressure angle of 20°, and a normal diametral pitch of 5 teeth/in. Find the axial circular pitches.
a) 1.2566 inches/tooth b) 1.6625 inches/tooth c) 1.6526 inches/tooth d) 1.6256 inches/tooth

Solution: $P_c = \frac{P_{cn}}{\cos\psi} = \frac{0.62832}{\cos 30^o} = 0.72552 \text{ inch/tooth}$ $\quad P_a = \frac{P_c}{\tan\psi} = \frac{0.72552}{\tan 30^o} = 1.2566 \text{ inches/tooth}$

34. A deep-groove ball bearing is to carry a radial load 800 lb and a thrust load 700 lb at 1800 rpm. The service is 8 hr/day, but it is not continuous; design for 18 250 hr. The operation is smooth with little vibration; the outer ring rotates. Determine the design life in million revolution (mr) with no more than 10 % failure.
a) 1791 mr **b) 1971 mr** c) 1197 mr d) 1917 mr

Solution: $B_{10} = (\text{Hrs})(60 \text{ min s/hr})(\text{rpm}) = \frac{(18250)(60)(1800)}{10^6} = 1971 \text{ mr}$

35. A shaft that transmits 1000 Hp at 1000 rpm is to be design with a square key. If the allowable shear and compressive stresses in the key are 15 ksi and 30 ksi, respectively, what length of the key is required?
a) **2.1 inches** b) 2.8 inches c) 3.2 inches d) 4.2 inches

Solution: Transmitted torque, $T = \frac{63000 \text{ Hp}}{n} = \frac{63000(1000)}{1000} = 63000 \text{ in} \cdot \text{lb}$

Key width, $b \approx \frac{D}{4}$, for good proportion

Key length based on shear, $L = \frac{2T}{s_s b D} = \frac{2(63000)}{15000(1)(4)} = 2.1 \text{ inches}$

Key length based on compression, $L = \frac{4T}{s_c t D} = \frac{4(63000)}{30000(1)(4)} = 2.1$ Therefore, use L = 2.1 inches

36. Two shafts, both 2.5 inches in diameter, is to be connected by a flange coupling. It is to transmit 15,000 in-lb of torque. How many ½" diameter bolts in a 6" diameter bolt circle are required if the shear stress in each bolt is limited to 3000 psi?
a) 9 bolts b) 7 bolts c) 6 bolts d) 8 bolts

Solution: No. of bolts, $n_b = \dfrac{8T}{\pi s_{sb} d^2 D_b} = \dfrac{8(15000)}{\pi(3000)(0.5)^2(6)} = 8.5 \text{ bolts}$ Use, n_b = 9 bolts

37. A wheel has an outside and inside diameter of 1 meter and 0.75 meter, respectively. If its arms and hub is neglected, determine the radius of gyration of the wheel.
a) 0.5125 m b) 0.6125 m c) **0.3125 m** d) 0.4125 m

Solution: $k = \sqrt{\dfrac{I}{A}} = \sqrt{\dfrac{\frac{\pi}{64}\left(D_o^4 - D_i^4\right)}{\frac{\pi}{4}\left(D_o^2 - D_i^2\right)}} = \sqrt{\dfrac{1}{16}\left[\dfrac{\left(D_o^2 + D_i^2\right)\left(D_o^2 - D_i^2\right)}{D_o^2 - D_i^2}\right]} = \dfrac{1}{4}\sqrt{D_o^2 + D_i^2} = 0.3125 \text{in.}$

38. Two sleeve bearings support a shaft. The total load on the bearings is 2800 lb. Diameter of the shaft is 1.75 inch. Find the friction power loss, in Hp, if the coefficient of friction between shaft and bearing is 0.10 and the shaft rotates 200 rpm.
a) 0.88 Hp **b) 0.78 Hp** c) 0.98 Hp d) 0.68 Hp

Solution: $fHp = \dfrac{T_f n}{63000} = \dfrac{f F r n}{63000} = \dfrac{0.10(2800)\left(\frac{1.75}{2}\right)(200)}{(63000)} = 0.78$

Where, T_f = frictional torque, in-lb F = load, lb n = rpm r = bearing diameter, inches
f = coefficient of friction

39. A collar has an outside diameter of 4 inches and an inside diameter of 2 inches. If it is loaded with a 2000 lb and rotates at 50 revolution per minute, determine its Hp lost. Coefficient of friction is 0.15.
a) 0.7314 Hp **b) 0.3714 Hp** c) 0.4713 Hp d) 0.4371 Hp

Solution: $fHp = \dfrac{T_f n}{63000} = \dfrac{f W r_f n}{63000} = \dfrac{0.15(2000 \text{ lb})(1.56 \text{inches})(50 \text{ rpm})}{63000} = 0.3714$

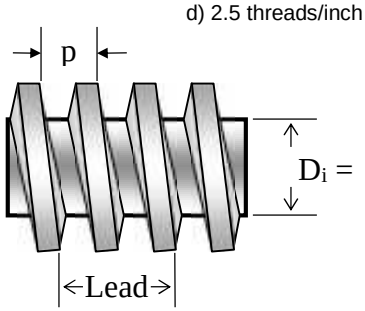
Where, $r_f = \dfrac{2}{3}\left(\dfrac{r_o^3 - r_i^3}{r_o^2 - r_i^2}\right) = \dfrac{2}{3}\left[\dfrac{(2)^3 - (1)^3}{(3)^2 - (1)^2}\right] = 1.56 \text{ inches}$

40. A double screw thread has a pitch of 0.2 inch. Its root diameter is 0.55 inch. Find the outside diameter and the number of thread per inch.
a) 0.2 threads/inch b) 10 threads/inch **c) 5 threads/inch** d) 2.5 threads/inch

Solution:

Solving for the outside or major diameter, $D_o = D_i + p = 0.55 + 0.2 = 0.75$ inch

Solving for the number of threads per inch, $TPI = \dfrac{1}{p} = \dfrac{1}{0.2} = 5 \text{ threads / inch}$



41. A driving pulley, 6 inches in diameter, carries a 6-inch wide and 1/3-inch flat belt that transmit 15Hp. The driving pulley rotates at 2000 rpm such that the loose side of the belt is on top. The driven pulley is 18 inches in diameter. The center distance is 8 ft. The belt material is 0.035 lb/in^3 and the coefficient of friction is 0.30. Determine the belt net tension.
a) 175.5 lb **b) 157.5 lb** c) 155.7 lb d) 165.7 lb

Solution: $F = F_1 - F_2 = \dfrac{2T}{D} = \dfrac{2}{D}\left(\dfrac{63000 \text{ Hp}}{n}\right) = \left(\dfrac{2}{6}\right)\left[\dfrac{63000(15)}{2000}\right] = 157.5 \text{ lb}$

Other Solution: $V_m = \pi D n = \pi\left(\dfrac{6}{12}\right)(2000) = 3141.59 \text{ fpm}$ $F = F_1 - F_2 = \dfrac{33000 \text{ Hp}}{V_m} = \dfrac{33000(15)}{3141.59} = 157.56 \text{ lb}$

42. A disc clutch is made of a material with coefficient of friction of 0.4. The shaft speed is 1200 rpm and axial force is 1500 N. The clutch has 6 pairs of contacting friction surfaces with an outside diameter of 200 mm and an inside diameter of 100 mm. Determine the Hp that can be transmitted by the clutch assuming uniform pressure.
a) 35.2 Hp b) 23.5 Hp **c) 47.2 Hp** d) 27.4 Hp

Solution: Friction Radius (Uniform pressure), $r_f = \frac{2}{3}\left(\frac{r_o^3 - r_i^3}{r_o^2 - r_i^2}\right) = \left(\frac{2}{3}\right)\left[\frac{(100)^3 - (50)^3}{(100)^2 - (50)^2}\right] = 77.78 \text{ mm}$

Friction Power or Transmitted Power or Power Capacity,

$$P = \frac{\pi n T_f}{30} = \frac{\pi n}{30}(F_f\ r_f\ n_f) = \frac{\pi n}{30}(f\ F_a\ r_f\ n_f) = \frac{\pi(1200)}{30}(0.4)(1.5)(0.07778)(6)$$

P = 35.19 kW = 47.2 Hp

Where, P = power capacity, kW; F_f = friction force, kN; T_f = torque capacity, kN-m; F_a = axial load, kN; R_f = friction radius or mean radius, m; n_f = no. of pairs of contacting friction surfaces

43. A flywheel is made up of cast iron with specific weight of 0.26 lb per cubic inch. It has a width of 8 inches, mean diameter of 4 ft and mean operating speed is 300 rpm and the coefficient of fluctuation is to be 0.05. It is required to handle 2250 ft-lb of kinetic energy. Find the weight of rim, assuming that the arms and hub are equivalent to 10 % of the total rim weight.
a) 333.7 lb b) 373.3 lb c) 337.3 lb d) 733.3 lb

Solution: $\Delta KE = \frac{1.10\,W}{g} C_f\ V^2$ $\qquad W = \frac{g(\Delta KE)}{1.10\,C_f\ V^2} = \frac{32.2(2250)}{1.10(0.05)(62.83)^2} = 333.7 \text{ lb}$

Where, $V = \text{mean velocity} = \frac{\pi D n}{60} = \frac{\pi(4)(300)}{60} = 62.83 \text{ fps}$ $\qquad$ C_f = coefficient of fluctuation

g = acceleration due to gravity = 32.2 fps^2 $\qquad$ ΔKE = Kinetic Energy

44. The axial pitch of a right-handed single-thread worm is 25 mm, normal pressure angle is 14.5°, and the pitch diameter of the worm is 100 mm. It is to be made from hardened steel which has a catalog rating of 2.25 kW at 650 rpm when meshed with a 48-tooth cast-steel gear. The coefficient of friction is 0.085. Determine the shafts center distance.
a) 241 mm b) 142 mm c) 412 mm d) 124 mm

Solution: $\text{Speed Ratio, } SR = \frac{\omega_w}{\omega_g} = \frac{n_w}{n_g} = \frac{T_g}{T_w} = \frac{D_g \cos\lambda}{D_w \sin\lambda} = \frac{D_g}{D_w \tan\lambda}$

$\text{Tan}\lambda = \frac{L}{\pi D_w} = \frac{p}{\pi D_w} = \frac{25}{\pi(100)} = 0.07958 \quad \rightarrow \quad \lambda = 4.55^o$

Pitch diameter of the gear, $D_g = \left(\frac{T_g}{T_w}\right) D_w \tan\lambda = \left(\frac{T_g}{T_w}\right) D_w \left(\frac{p}{\pi D_w}\right) = \left(\frac{T_g}{T_w}\right)\left(\frac{p}{\pi}\right) = \left(\frac{48}{1}\right)\left(\frac{25}{\pi}\right) = 381.97 \text{ mm}$

Center Distance, $C = \frac{D_w + D_g}{2} = \frac{100 + 381.97}{2} = 241 \text{ mm}$

45. For a bolted connection, specification suggests that a high grade material of 13 mm bolt be tightened to an initial tension of 55 000 N. What is the appropriate tightening torque?
a) 134 N-m **b) 143 N-m** c) 341 N-m d) 431 N-m

Solution: $T = C\,D\,F_i = (0.20)(0.013\,\text{m})(55\,000\ \text{N}) = 143\ \text{N}\cdot\text{m}$

Note: Initial Tension and tightening Torque, $T = C\,D\,F_i$

Where, T = tightening torque, N-m, kN-m, in-lb; F_i = initial tension, N, kN, lb
D = bold nominal diameter, inch, mm; C = torque coefficient
C = 0.20 (for as received bolts); C = 0.15 (for lubricated bolts)

46. A 74.6 kW engine of a hoist is capable of lifting 44 500 N of load at a height of 6.10 m in 10 seconds. What is the efficiency of the machine?
a) 36.39 % b) 39.36 % c) 63.39 % d) 93.36 %

Solution: $W = F \cdot V = (44\,500\ \text{N})\left(\frac{6.10\ \text{m}}{10\ \text{seconds}}\right) = 27145\ \text{W} = 27.145\ \text{kW}$ $\eta = \frac{27.145}{74.6}(100\ \%) = 36.39\ \%$

47. Calculate the peripheral speed, in fpm, of a short shaft held with 16 inches pulley and runs at 450 rpm.
a) 1588 b) 1858 **c) 1885** d) 5881

Solution: $V_m = \pi D n = (\pi)\left(\frac{16}{12}\right)(450) = 1884.96\ \text{fpm}$

48. An 18-inch high spring deflects 6 inches when strike by 100lb load. Find the average force acting on the spring.
a) 800 lb b) 600 lb c) 900 lb d) 700 lb

Solution: $W(h+\delta) = \left(\frac{1}{2}\right)F\delta$ $F = \frac{2W(h+\delta)}{\delta} = \frac{2(100)(18+6)}{6} = 800\ \text{lb}$

49. A carbon steel UNC bolt has a stress area of 0.606 in^2, determine its permissible working stress.
a) 4055.49 psi b) 4505.49 psi c) 4550.49 psi d) 4455.09 psi

Solution: $s_w = C(A_r)^{0.418} = (5000)(0.606)^{0.418} = 4055.49\ \text{psi}$

Note: From Vallance, p138. Bolt permissible stress, $s_w = C(A_r)^{0.418}$ Applied load, $F_a = s_w A_r = C(A_r)^{1.418}$

Where, C = 5000 for carbon steel bolt C = 15 000 for alloy-steel bolts C = 1 000 for bronze bolts

50. The allowable working stress of a 1.5 inches bolt which is screwed up tightly in packed joint is 13000psi, determine the working strength.
a) 11 212.5 lb b) 10 212.5 lb c) 12 212.5 lb d) 13 212.5 lb

Solution: From Machinery's Handbook, $W = s_t(0.55d^2 - 0.25d) = (13\,000)\left[0.55(1.5)^2 - 0.25(1.5)\right] = 11\,212.5\ \text{lb}$

Where, W = working strength, lb s_t = allowable working stress, psi d = nominal diameter, inch

51. A shaft is made of a material that weighs 0.28 lb/in^3 and a modulus of elasticity of 30 x 10^6 psi. Bearings, 90 inches apart, support the 2-inch shaft that carries no rotating disc. The shaft has a uniform cross section. Find the second critical speed, in rpm.
a) 4217.28 rpm b) 4172.28 rpm c) 4228.17 rpm d) 4712.28 rpm

Solution: Lowest critical speed, $N = 4270\,000\left(\frac{D}{L^2}\right) = (4\,270\,000)\left[\frac{2}{(90)^2}\right] = 1054.32\ \text{rpm}$

Second Critical Speed, $N_2 = 4(1054.32) = 4217.28\ \text{rpm}$

Note: The next critical speeds from the lowest critical speed can be found by multiplying by 4, 9, 16, 25, and so on.

52. A 75 lb disc is mounted midway a 1-inch diameter shaft supported by bearings 20 inches apart. Find the lowest critical speed in rpm. Neglect the weight of the shaft. Assume that the modulus of elasticity is 30 000 000 psi.
a) 5763.43 rad/s **b) 301.77 rad/s** c) 1207.09 rad/s d) 401.77 rad/s

Solution: For the disc mounted midway between bearings (neglecting shaft weight),

$$\omega_{cr} = \sqrt{\frac{576EIg}{WL^3}} = \sqrt{\frac{576(30\,000\,000)(0.0982)(32.2)}{(75)(20)^3}} = 301.77\ \text{rad/s}$$

Where, $I = \frac{\pi}{32}D^4 = \left(\frac{\pi}{32}\right)(1)^4 = 0.0982\ \text{in}^4$

53. A 4-inch wide and 0.25-inch thick leather belt turns at 3601 fpm. Compute for its centrifugal force.
a) 47 lb b) 74 lb c) 57 lb d) 75 lb

Solution: $F_c = \dfrac{12\,\gamma\, b\, t\, V_s^2}{g} = \dfrac{12\,(0.035)(4)(0.25)\left(\dfrac{3601}{60}\right)^2}{32.2} = 46.98 \text{ lb}$

Note: Specific weight of leather belt = 0.035 lb/in^3 Specific weight of rubber belt = 0.045 lb/in^3

54. A 2-foot pulley rotating at 600 rpm carries a ¼-inch thick belt that transmits 30 Hp of power. The allowable belt stress is 500 psi; the angle of contact is 150°. Find the belt width required, assuming the coefficient of friction is 0.4 and the specific weight of the belt material is 0.035 lb/in^3.
a) 2.61 inches **b) 3.61 inches** c) 4.61 inches d) 5.61 inches

Solution: $F_t = \left(\dfrac{2}{D}\right)\left(\dfrac{63\,000\,Hp}{n}\right) = \dfrac{2(63\,000)(30)}{(2)(12)(600)} = 262.5 \text{ lb}$ $\qquad V_m = \pi D n = (\pi)(2)(600) = 3769.91 \text{ fpm}$

$$F_t = \frac{33\,000\ Hp}{V_m} = \frac{(33\,000)(30)}{3769.91} = 262..61 \text{ lb}$$

$$F_t = F_1 - F_2 = bt\left(s - \frac{12\,\gamma\, V_2^2}{g}\right)\left(\frac{e^{f\theta} - 1}{e^{f\theta}}\right) \qquad b = \frac{F_t}{t\left(s - \frac{12\,\gamma\, V_s^2}{g}\right)\left(\frac{e^{f\theta} - 1}{e^{f\theta}}\right)}$$

$$b = \frac{262.61}{0.25\left[500 - \dfrac{12\,(0.035)\left(\dfrac{3769.91}{60}\right)^2}{32.2}\right]\left(\dfrac{e^{0.40(150)(\pi/180^\circ)} - 1}{e^{0.4(150)(\pi/180)}}\right)} = \frac{262.61}{112.13\left(\dfrac{1.8497}{2.8497}\right)} = 3.608 \text{ inches}$$

55. Find the total torque necessary to raise the load of 3000 lb using a triple-thread square power screw. The power screw has a root diameter of 2 inches and 2 threads per inch. It is used in conjunction with a collar with an outer diameter of 4 inches and an inner diameter of 2.5 inches. The coefficient of friction is 0.2 for both threads and collar.
a) 2445 lb b) 2544 lb c) 2454 lb d) 4245 lb

Solution: Pitch, $P_a = \dfrac{1}{TPI} = \dfrac{1}{2} = 0.5 \text{ inch / thread}$

Major diameter, $D_o = D_i + 2h = D_i + 2\left(\dfrac{P_a}{2}\right) = D_i + P_a = 2 + 0.5 = 2.5 \text{ inches}$

Mean diameter, $D_m = \dfrac{D_i + D_o}{2} = \dfrac{2 + 2.5}{2} = 2.25 \text{ inches}$

Collar mean radius or friction radius, $r_c = \left(\dfrac{2}{3}\right)\left(\dfrac{r_o^3 - r_i^3}{r_o^2 - r_i^2}\right) = \left(\dfrac{2}{3}\right)\left[\dfrac{(2)^3 - (1.25)^3}{(2)^2 - (1.25)^2}\right] = 1.654 \text{ inches}$

Lead Angle, $\text{Tan}\lambda = \dfrac{L}{\pi D_m} = \dfrac{N_t P_a}{\pi D_m} = \dfrac{(3)(0.5)}{\pi(2.25)} = 0.21221$ $\qquad \lambda = 11.98^\circ$

Total Torque, $T = T_c + T_s = f_c\, W\, r_c + \dfrac{W\, D_m}{2}\left(\dfrac{\text{Tan}\lambda + f}{1 - f\ \tan\lambda}\right)$

$$T = (0.2)(3000)(1.654) + \left[\frac{3000(2.25)}{2}\right]\left[\frac{0.21221 + 0.2}{1 - 0.2(0.21221)}\right] = 2445.27 \text{ in} \cdot \text{lb}$$

56. Find the efficiency of a triple-thread square power screw raising a load of 3000 lb. The power screw has a root diameter of 2 inches and 2 threads per inch. It is used in conjunction with a collar with an outer diameter of 4 inches and an inner diameter of 2.5 inches. The coefficient of friction is 0.2 for both threads and collar.
a) 25.25 % b) 39.29 % **c) 29.29 %** d) 24.29 %

Solution: $e = \dfrac{\tan\lambda(1 - f\tan\lambda)(100\ \%)}{\tan\lambda + f + \left(\dfrac{f_c D_c}{D_m}\right)(1 - f\tan\lambda)} = \dfrac{(0.21221)[1-(0.2)(0.21221)](100\ \%)}{0.21221 + 0.2 + \left[\dfrac{0.2(3.308)}{2.25}\right][1-(0.2)(0.21221)]} = 29.29\ \%$

57. The depth of water in a pond is 5 m. What is its depth in fathom?
a) 2.73 fathoms b) 3.72 fathoms c) 1.73 fathom d) 7.13 fathoms

Solution: $\text{depth} = (5\ \text{m})\left(3.28\ \dfrac{\text{ft}}{\text{m}}\right)\left(\dfrac{1\ \text{fat hom}}{6\ \text{feet}}\right) = 2.73\ \text{fat hom}$

58. A container has a capacity of 30 barrels. What is its equivalent volume in m^3?
a) 4.77 m^3 b) 7.74 m^3 c) 3.77 m^3 d) 5.77 m^3

Solution: $V = (30\ \text{barrels})\left(\dfrac{42\ \text{gallons}}{1\ \text{barrel}}\right)\left(\dfrac{3.7854\ \text{liters}}{1\ \text{gallon}}\right)\left(\dfrac{1\ \text{m}^3}{1000\ \text{liters}}\right) = 4.77\ \text{m}^3$

59. A bridge has a span of 5 furlongs. What is its equivalent length in yards?
a) 1000 yards b) 1150 yards **c) 1100 yards** d) 1150 yards

Solution: $L = (5\ \text{furlong})\left(\dfrac{220\ \text{yards}}{1\ \text{Furlong}}\right) = 1100\ \text{yards}$

60. Determine the kinetic energy needed in punching of 350 kg flywheel if the speed varies from 200 rpm to 180 rpm with 1 m mean diameter.
a) 3.65 kJ b) 6.28 kJ c) 4.51 kJ d) 5.62 kJ

Solution: $V_1 = \dfrac{\pi D n_1}{60} = \dfrac{\pi(1\ \text{m})(200)}{60} = 10.47\ \text{m/s}$ $\quad V_2 = \dfrac{\pi D n_2}{60} = \dfrac{\pi(1\ \text{m})(180)}{60} = 9.42\ \text{m/s}$

$$\Delta KE = \frac{m}{2}\left(V_1^2 - V_2^2\right) = \left(\frac{350\ \text{kg}}{2}\right)\left[(10.47)^2 - (9.42)^2\right] = 3654.8\ \text{J} = 3.655\ \text{kJ}$$

61. A punch machine uses 10 kJ of energy to punch a square in 20 mm thick plate. If the ultimate strength of the plate is 420 MPa, determine the maximum sides of square that can be punched.
a) 45 mm **b) 30 mm** c) 60 mm d) 55 mm

Solution: $\Delta KE = \dfrac{1}{2}F\cdot t_p = \dfrac{1}{2}(4bt_p)t_p s_u = \dfrac{1}{2}(4b)t_p^2 s_u = 2b(t_p)^2 s_u$ $\quad b = \dfrac{\Delta KE}{2t_p^2 s_u} = \dfrac{10\,000\,000\ \text{N}\cdot\text{mm}}{2(20\ \text{mm})^2(420\ \text{N/mm}^2)} = 29.76\ \text{mm}$

62. A steel rod of 6 inches long is to resist an impact load of 500 lb dropped through a distance of 2 inches. If the maximum computed stress is to be 20 ksi, determine the required diameter of the rod.
a) 5.65 inches b) 6.55 inches c) 4.65 inches d) 6.45 inches

Solution: Maximum deflection due to the maximum stress, $\delta = \dfrac{sL}{E} = \dfrac{(20\,000\ \text{psi})(6\ \text{inches})}{30\ \text{x}\ 10^6\ \text{psi}} = 0.004\ \text{inch}$

Solving for cross sectional area, $s = \dfrac{2W}{A}\left(\dfrac{h}{\delta} + 1\right)$ $\quad A = \dfrac{2W}{s}\left(\dfrac{h}{\delta} + 1\right) = \left[\dfrac{2(500\ \text{lb})}{20\,000\ \text{lb/in}^2}\right]\left(\dfrac{2}{0.004} + 1\right) = 25.05\ \text{in}^2$

Solving for the Diameter, $D = \sqrt{\dfrac{4A}{\pi}} = \sqrt{\dfrac{4(25.05)}{\pi}} = 5.65\ \text{inches}$

63. A punch machine uses 10 kJ of energy to punch a square in 20 mm thick plate. If the ultimate strength of the plate is 420 MPa, determine the maximum sides of square that can be punched if a factor of safety of 4 is to be applied.
a) 25 mm b) 35 mm **c) 30 mm** d) 20 mm

Solution: Punching Force, $F = \frac{2(\Delta KE)}{t_p} = \frac{2(10\,000\ \text{N}\cdot\text{m})}{0.02\,\text{m}} = 1\,000\,000\ \text{N} = 1000\ \text{kN}$

$$b = \frac{F}{4 s_u t_p} = \frac{1000\ 000\ \text{N}}{4(420\ \text{N/mm}^2)(20\ \text{mm})} = 29.76\ \text{mm} \approx 30\ \text{mm}$$

64. How many turns a flywheel makes before it stops from a speed of 220 rpm? The flywheel stops in 15 seconds.
a) 27.5 turns b) 172.8 turns c) 25.7 turns d) 52.7 turns

Solution: Acceleration, $\alpha = \frac{\omega_f - \omega_o}{t} = \frac{0 - 23.04}{15} = -1.536\ \text{rad/s}^2$ $\omega_o = \frac{2\pi n}{60} = \frac{2(\pi)(220)}{60} = 23.04\ \text{rad/s}$

Angular displacement, $\theta = \omega_o t + \frac{\alpha}{2} t^2 = (23.04)(15) + \left(\frac{-1.536}{2}\right)(15)^2 = 172.8\ \text{radians} = 27.5\ \text{revolutions}$

65. Determine the cutting speed, in fpm, of a workpiece with 2 inches diameter and running at 100 rpm.
a) 56.23 fpm **b) 52.36 fpm** c) 36.52 fpm d) 23.56 fpm

Solution: $V = \pi D n = (\pi)\left(\frac{2}{12}\right)(100) = 52.36\ \text{fpm}$

66. A 40 kg load falls through a height of 0.20 m before striking the free end of a cantilever beam. The beam is 60 mm wide and 100 mm deep. Compute the maximum bending stress and deflection caused by the impact. Neglect the mass of the beam and assume that the 40 kg mass remains in contact with the beam.
a) 162 MPa b) 261 MPa c) 126 MPa d) 621 MPa

Solution: Static stress,

$$s_{st} = \frac{Mc}{I} = \frac{W L c}{I} = \frac{mg L\left(\frac{h}{2}\right)}{\frac{bh^3}{12}} = \frac{6 m g L}{b h^2} = \frac{6(40\,\text{kg})(9.8066\ \text{m/s}^2)(2\ \text{m})}{(0.06\ \text{m})(0.10\ \text{m})} = 7\,845\,280\ \text{N/m}^2 = 7.85\ \text{MPa}$$

Moment of Inertia, $I = \frac{b h^3}{12} = \frac{(0.06)(0.10)^3}{12} = 5\ \text{x}\ 10^{-6}\ \text{m}^4$

Deflection of Cantilever, $\delta = \frac{W L^3}{3 E I} = \frac{(40)(9.806)(0.10)^3}{3(20\,000\,000\,000\ \text{N/m}^2)(5\ \text{x}\ 10^{-6}\ \text{m}^4)} = 1.046\ \text{x}\ 10^{-3}\ \text{m} = 1.046\ \text{mm}$

Maximum Stress caused by the Impact, $s_{max} = \frac{W}{A} + \frac{W}{A}\left(1 + \frac{2hEA}{WL}\right)^{0.5} = s_{max} = s_{st} + s_{st}\left(1 + \frac{2h}{\delta}\right)^{0.5}$ Where, $\delta = \frac{WL}{AE}$

$$s_{max} = 7.85 + 7.85\left[1 + \frac{2(0.20)}{1.046\ \text{x}\ 10^{-3}}\right]^{0.5} = 161.56\ \text{MPa} \approx 162\ \text{MPa}$$

67. A double thread worm gear has a pitch of 1.125 inches and a pitch diameter of 3 inches. It has a coefficient of friction of 0.20 and normal pressure angle of 14.5°. The worm is supplied by 12 Hp at 1200 rpm motor. Find the tangential force on the gear. The worm is a left hand thread.
a) 420 lb **b) 897 lb** c) 798 lb b) 879 lb

Solution: $\lambda = \tan^{-1}\left(\frac{L}{\pi D_w}\right) = \tan^{-1}\left(\frac{N_t P_a}{\pi D_w}\right) = \tan^{-1}\left[\frac{2(1.125)}{\pi(3)}\right] = 13.427^o$

Tangential load of worm, $F_{tw} = \left(\frac{2}{D_w}\right)\left(\frac{63\,000\,Hp}{n_w}\right) = \left(\frac{2}{3}\right)\left[\frac{63\,000(12)}{1200}\right] = 420\ lb$

Tangential load on gear, $F_{tg} = F_{tw}\left(\frac{\cos\phi_n \cos\lambda - f\sin\lambda}{\cos\phi_n \sin\lambda + f\cos\lambda}\right) = (420)\left(\frac{\cos 14.5^o \cos 13.427^o - 0.20\sin 13.427^o}{\cos 14.5^o \sin 13.427^o + 0.20\cos 13.427^o}\right) = 896.65\ lb$

68. A double thread worm has a lead angle of 7.25° and pitch radius of 2.5 inches. Determine the pitch of the worm.
a) 1.5 inch b) 2 inches **c) 1 inch** d) 0.75 inch

Solution: $L = \pi D_w \tan\lambda = 2\pi R \tan\lambda = 2(\pi)(2.5)\tan 7.25^o = 1.9983$ inches $\quad P_a = \frac{L}{N_t} = \frac{1.9983}{2} = 0.9992$ inch ≈ 1 inch

69. 6 cm and 12 cm diameter pulleys are used to transmit power. Center distance of the pulleys is 72 cm. If an open belt arrangement is used, calculate the required belt length.
a) 127.4 cm b) 142.7 cm **c) 172.4 cm** d) 147.2 cm

Solution: $L = \left(\frac{\pi}{2}\right)(D_1 + D_2) + 2C + \frac{(D_2 - D_1)^2}{4C} = \left(\frac{\pi}{4}\right)(6+12) + 2(72) + \frac{(12-6)^2}{4(72)} = 172.4$ cm

70. Determine the depth of the ACME thread if the pitch is 1.25 inches.
a) 0.625 inch **b) 0.635 inch** c) 1.25 inches d) 0.750 inch

Solution: $h = 0.5\,P_a + 0.01 = (0.5)(1.25) + 0.01 = 0.635$ inch

71. A chain and sprocket has 18 teeth with chain pitch of 0.5 inch. Find the pitch diameter of the sprocket.
a) 2.88 inches b) 2.66 inches c) 2.55 inches d) 2.77 inches

Solution: $D = \frac{P_a}{\sin\left(\frac{180^o}{T}\right)} = \frac{0.50}{\sin\left(\frac{180^o}{18}\right)} = 2.879$ inches

72. The ratio in band tension in a brake drum is 3. The difference between the tight side and slack side is 5 kN. Find the tension in the tight side.
a) 2.75 kN **b) 3.75 kN** c) 4.75 kN d) 1.75 kN

Solution: $F_1 = 3F_2 \qquad F_1 = 5 - F_2 = 5 - \frac{F_1}{3}$ $\qquad F_1 = 3.75$ kN

73. What will be the resulting critical speed of a shaft if you double its diameter? The original critical speed of the shaft is 800 rpm.
a) 1600 rpm b) 3600 rpm c) 800 rpm d) 900 rpm

Solution: $n_{cr} = 4\,270\,000\left(\frac{D}{L^2}\right) \qquad \frac{D}{L^2} = \frac{n}{4\,270\,000} = \frac{800}{4\,270\,000}$

$$n_{cr} = (4270\,000)(2)\left(\frac{800}{4270000}\right) = 1600\,\text{rpm}$$

74. A 112.5 mm shaft is keyed to a pulley. The pulley is made of a cast iron material and has a diameter of 1200 mm. The key is 28.13 mm square key and 175 mm long. The key and shaft have a shearing stress of 14 000 psi. Determine the force acting at the pulley that will shear the key.
a) 4541.83 kg b) 4252.83 kg c) 5441.83 kg d) 4145.83 kg

Solution: $F_p = \frac{2T}{D_p} = \frac{2\left(\frac{s_s bLD}{2}\right)}{D_p} = s_s bL\left(\frac{D}{D_p}\right) = (14000)\left(\frac{28.13}{25.4}\right)\left(\frac{175}{25.4}\right)\left(\frac{112.5}{1200}\right) = 10014.74$ lb

75. A flanged coupling is used in a 75-mm shaft that transmits 300 kW of power at 600 rpm. The coupling has 6 bolts, each 18 mm in diameter. Find the required diameter of the bolts circle based on an average shearing stress of 27.5 MPa.

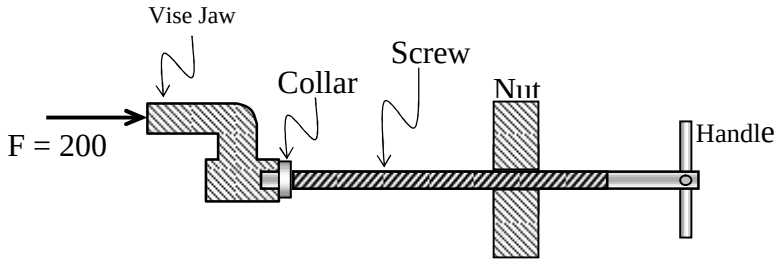
a) 8.95 inches b) 5.98 inches c) 9.85 inches d) 7.95 inches

Solution: $D_B = \dfrac{8T}{\pi s_s d^2 n_B} = \dfrac{8(30)P}{\pi^2 d^2 s_s n\, n_B} = \dfrac{8(30)(300)}{\pi^2 (0.018)^2 (27\,500)(600)(6)} = 0.2274 \text{ m} = 227.4 \text{ mm}$

76. A bolt is screwed up tightly in a packed joint. The allowable working stress is 12,000 psi and size of the bolt is 2 inches. Determine its working strength.
a) 20 120 lb b) 20 100 lb **c) 20 400 lb** d) 20 200 lb

Solution: From Machinery's handbook: $W = s_t\left(0.55d^2 - 0.25d\right) = (12\,000)\left[0.55(2)^2 - 0.25(2)\right] = 20\,400 \text{ lb}$

77. A 1-inch single square thread, with 4 threads per inch, is used in a vise mechanism. The frictional radius of the collar is 0.5 inch. The coefficient of friction for both the collar and threads is 0.20. How much external torque must be applied to produce a force of 200 lb against the jaws of the vise?
a) 39.73 in-lb b) 33.97 in-lb **c) 37.93 in-lb** d) 39.37 in-lb



Solution:

For the thread pitch,

$$p = \frac{1}{\text{Number of Threads per Inch}} = \frac{1}{4} = 0.25 \text{ inch}$$

For the minor diameter, $D_i = D_o - p = 1 - 0.25 = 0.75$ inch

For the mean or pitch diameter of the screw, $D_m = \dfrac{D_o + D_i}{2} = \dfrac{1 + 0.75}{2} = 0.875$ inch

For the lead angle, $\lambda = \tan^{-1}\left(\dfrac{L}{\pi D_m}\right) = \tan^{-1}\left(\dfrac{p}{\pi D_m}\right) = \tan^{-1}\left(\dfrac{0.25}{0.875\pi}\right) = \tan^{-1} 0.09095 = 5.197^\circ$

Solving for the torque required to overcome the collar friction, $T_c = \dfrac{fFD_c}{2} = \dfrac{(0.2)(200)(0.5)}{2} = 20 \text{ in} \cdot \text{lb}$

Solving for the torque required to overcome the thread friction,

$$T_s = \frac{FD_m}{2}\left(\frac{\tan\lambda + f}{1 - f\tan\lambda}\right) = \frac{200(0.875)}{2}\left[\frac{0.09095 + 0.2}{1 - 0.2(0.9095)}\right] = 25.93 \text{ in} \cdot \text{lb}$$

Solving for the total torque, $T = T_s + T_c = 25.93 + 20 = 45.93$ inches ans.

78. A hollow shaft with inside diameter of 1 inch is to replace a 1.5-inch diameter solid shaft in a power transmission. Considering equal torsional strengths, determine the required outside diameter of the hollow shaft.
a) 2.25 in. b) 1.5 in. c) **1.75 in.** d) 2.0 in.

Solution: $Ss_{solid} = \dfrac{16T}{\pi D^3}$ $Ss_{hollow} = \dfrac{16TD_o}{\pi(D_o^4 - D_1^4)}$

Thus, for equal strength, $D_o^4 - 1 = D_o(1.5)^3 : D_o = 1.589\text{in}.$ Use the next higher standard size, D_o=1.75 in.

79. A square key is used in a 4-inch diameter shaft transmitting 1000 hp at 1000 rpm. If the allowable shear and compressive stresses in the key are 15 ksi and 30 ksi, respectively, what length of key is required?
a) **53.34 mm** b) 54.33 mm c) 50.34 mm d) 55.34 mm

Solution: Transmitted torque, $T = \frac{63000\,Hp}{n} = \frac{63000(1000)}{1000} = 63000\ \text{in}\cdot\text{lb}$

Key width, $b \approx \frac{D}{4}$, for good proportion

Key length based on shear, $L = \frac{2T}{s_s b D} = \frac{2(63000)}{15000(1)(4)} = 2.1\ \text{inches}$

Key length based on compression, $L = \frac{4T}{s_c\, t\, D} = \frac{4(63000)}{30000(1)(4)} = 2.1$

Therefore, use L = 2.1 inches

80. A steel shaft, with a modulus of rigidity of 12 x 10^6 psi, transmits 40 Hp at 1400 rpm. It is 1.4375 inches in diameter. Find the torsional deflection of the shaft in degrees per foot length.
a) 0.246 b) 0.624 c) 0.426 d) 1.246

Solution: $\frac{\theta}{L} = \frac{T}{JG} = \frac{32T}{\pi D^4 G} = \frac{32(63000\,Hp)}{\pi n D^4 G} = \frac{32(63000)(40)(12)}{\pi(1400)(1.4375)^4(12\ x\ 10^6)}\left(\frac{180^o}{\pi}\right) = 0.246\ \text{radian}$

81. What torque is needed by a flywheel to produce an angular acceleration of 100 revolutions per minute, per second? The flywheel is solid disk and has a diameter of 1.5 m and a mass of 800 kg.
a) 3265 N-m b) 5236 N-m c) **2356 N-m** d) 6325 N-m

Solution: $\text{Torque} = \text{Mass Moment of Inertia x AngularAcceleration} = I\alpha$

Where, $I = \frac{1}{2}mr^2$, for cylinders; $I = \frac{1}{2}(800\text{kg})(1.5/2)^2\,\text{m}^2 = 225\text{kg}\cdot\text{m}^2$

Then, $T = (225)\text{kg}-\text{m}^2\left[\frac{100(2\pi)}{60}\right]\frac{\text{rad}}{\text{s}^2} = 2356.2\ \text{N}\cdot\text{m}$

82. A brass plate with thickness of ¼ inches is to punch a 2 inches diameter hole. Find the pressure required.
a) 40 tons **b) 32.5 tons** c) 20.5 tons d) 35 tons

Solution: $F = 65\,d\,t = (65)(2)(0.25) = 32.5\ \text{tons}$

[For steel plate use 80 as constant] (From Machinery's Hand Book, 26th Ed.)

83. A bolt is screwed up tightly in a packed joint. The allowable working stress is 12,000 psi and size of the bolt is 1.5 inches. Determine its working strength
a) 12 121.5 lb **b) 11 212.5 lb** c) 21 211.5 lb d) 12 211.5 lb

Solution: $W = S_t\left(0.55D^2 - 0.25D\right) = (13000)\left[(0.55)(1.5)^2 - (0.25)(1.5)\right] = 11212.5\ \text{lb}$

[From Machinery's Hand Book, 26th Ed., p1489]

84. A collar has an outside diameter of 100 mm and an inside 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. Determine the frictional Power acting on a collar loaded with 100 kg weight.
a) 572 W b) 527 W c) 752 W d) 275 W

Solution: $r_f = \left(\frac{2}{3}\right)\left(\frac{r_o^3 - r_i^3}{r_o^2 - r_i^2}\right) = \left(\frac{2}{3}\right)\left[\frac{(50)^3 - (20)^3}{(50)^2 - (20)^2}\right] = 37.14\ \text{mm} = 0.03714\,\text{m}$

$T_f = f\ W\ r_f = (0.15)(100\,\text{kg})(9.8066\,\text{N/kg})(0.03714\ \text{m}) = 5.464\ \text{N}\cdot\text{m}$

$P_f = \frac{\pi n T_f}{30} = \frac{\pi(1000)(5.464)}{30} = 572.2\ \text{W} = 0.572\ \text{kW}$

85. Mechanical power at a rate of 37 kW running at 1760 rpm is to transmit using a solid shaft 48.2 cm long. The torsional stress is 8.13 MPa. What is the diameter of the shaft?
a) 45 mm **b) 50 mm** c) 55 mm d) 30 mm

Solution: $T = \frac{30\,P}{\pi\,n} = \frac{(30)(37)}{\pi(1760)} = 0.20075\ \text{kN}\cdot\text{m} = 200.75\ \text{N}\cdot\text{m}$ $\quad D = \left(\frac{16\,T}{\pi\,S_s}\right)^{\frac{1}{3}} = \left[\frac{16(200\,750\ \text{N}\cdot\text{mm})}{\pi(8.13\ \text{N/mm}^2)}\right]^{\frac{1}{3}} = 50.10\ \text{mm}$

86. An integral gear with diameter D is set up with a 127-mm diameter pinion and center distance of 457.2 mm. Calculate D.
a) 1140.4 mm b) 1410.4 mm **c) 1041.4 mm** d) 1104.4 mm

Solution: $D_2 = 2C + D_1 = 2(457.2) + 127 = 1041.4\ \text{mm}$

87. An air compressor system uses a receiver with 30 inches diameter and pressure load of 120 psi. Consider a design stress of 8000 psi, calculate the thickness required of the receiver if it is to be oriented vertically, cylindrical and to be made from steel.
a) 3/16 inch b) 3/8 inch c) 5/16 inch **d) ¼ inch**

Solution: $t = \frac{pD}{2\,S_t} = \frac{(120\ \text{psi})(30\ \text{inches})}{2(8000\ \text{psi})} = 0.225\ \text{inch} \approx 1/4\ \text{inch}$

88. A 36-tooth gear drives a 50.8-mm solid shaft that transmits power at 120 rpm. If the allowable shearing stress is 83 MPa, determine the power transmitted, in Hp.
a) 36 Hp b) 28 Hp c) 42 Hp d) 38 Hp

Solution: $T = \frac{\pi D^3 s_s}{16} = \frac{\pi(50.8\ \text{mm})^3(83\ \text{N/mm}^2)}{16} = 2136\,461.415\ \text{N}\cdot\text{mm}$

$P = \frac{\pi\,n\,T}{30} = \frac{\pi(120)(2.14)}{30} = 26.89\ \text{kW} = 36.05\ \text{Hp}$

89. A helical spring has an outside diameter of 10.42 cm and a wire diameter of 0.625 cm. The spring has squared and ground ends and a total of 18 coils. Its material has modulus of elasticity in shear of 78.91 GPa. Determine the deflection in the spring due to a load of 50 kg.
a) 490 mm b) 409 mm c) 390 mm d) 309 mm

Solution: $\delta = \frac{8F(D_w)^3 N_a}{G(d_w)^4} = \frac{8FC^3 N_a}{G d_w}$ Where, for S & G ends: $N_a = N - 2 = 18 - 2 = 16\ \text{coils}$

$C = \frac{D_m}{d_w} = \frac{D_o - d_w}{d_w} = \frac{10.42 - 0.625}{0.625} = 15.672$ $\quad \delta = \frac{8(50\,\text{kg})(9.8066\ \text{N/kg})(15.672)^3(16)}{(78\,910\ \text{N/mm}^2)(6.25\ \text{mm})} = 489.85\ \text{mm}$

90. A tank is to construct in a gasoline station and its seams are to be weld using electric arc welding. With a rate of 18 in/min, how long will it takes to weld a 0.5 inch thick plate by 3 ft long seam?
a) 1.5 minutes b) 3 minutes **c) 2 minutes** d) 2.5 minutes

Solution: $t = \frac{\text{Length}}{\text{Rate of Welding}} = \frac{(3\ \text{ft})(12\ \text{inches/ft})}{18\ \text{in/min}} = 2\ \text{minutes}$

91. A machine shop is to mill a 0.75 inch by 2 inches keyway in a 3 inches diameter shafting with 24-tooth cutter turning at 100 rpm. If the mill has a rate of 0.005" feed per tooth, how long will it take to mill the keyway?
a) 10 seconds b) 8 seconds c) 12 seconds d) 15 seconds

Solution: $t = \frac{\text{Length}}{(\text{No. of Teeth/rev})(\text{Feed, inch/tooth})(\text{rpm})} = \frac{2\ \text{inches}}{(24\,\text{teeth/rev})(0.005\ \text{in/tooth})(100\ \text{rpm})} = 0.1667\ \text{min}$

92. A 14½° spur gear has a pitch of 4. Calculate its tooth thickness.
a) 0.3927 inch b) 9.975 mm c) 0.9975 cm **d) Any of these**

Solution: $t = \dfrac{1.5708}{P_d} = \dfrac{1.5708}{4} = 0.3927 \text{ inch} = 9.975 \text{ mm} = 0.9975 \text{ cm}$

93. A pump uses a journal bearing with diameter of 76.2 mm is subjected to a load of 4.9 kN while rotating at 200 rpm. If its coefficient of friction is 0.02 and L/D = 2.5, find its projected area, in mm^2
a) 41 516.1 mm^2 **b) 14 516.1 mm^2** c) 15 416.1 mm^2 d) 16 416.1 mm^2

Solution: $L = 2.5\,D = (2.5)(76.2) = 190.5 \text{ mm}$ Projected Area, $A = D(L) = (76.2 \text{ mm})(190.2 \text{ mm}) = 14\,516.1 \text{ mm}^2$

94. Determine the diameter of a line shaft transmitting 12 Hp at 180 rpm with torsional deflection of 0.08 degree per foot length.
a) 2.75 inches **b) 2.34 inches** c) 2.25 inches d) 3.34 inches

Solution: $D = 4.6\left(\dfrac{P}{N}\right)^{0.25} = (4.6)\left(\dfrac{12}{180}\right)^{0.25} = 2.34 \text{ inches}$

Where, P = power transmitted, Hp N = n = rpm of the shaft

Note: This equation is for torsional deflection of 0.08 degree per ft length and using G = 12 x 10^6 psi.

Derived from the equations: $\dfrac{\theta}{L} = \dfrac{32\,T}{\pi D^3\,G}$ and $Hp = \dfrac{T\,n}{63\,000}$

95. Calculate the maximum unit shear in a 3-inch diameter steel shaft transmitting 2400 in-lb of torque at 180 rpm.
a) 453 psi b) 543 psi c) 435 psi d) 534 psi

Solution: $s_s = \dfrac{16\,T}{\pi\,D^3} = \dfrac{(16)(2400)}{\pi(3)^3} = 452.71 \text{ psi}$

96. A 1.5-inch diameter shaft has a driver with variable torque. Shaft has a yield strength of 60000 psi. If torque varies from 2000 to 6000 in-lb, determine the shaft mean or average stress.
a) 6 036.10 psi b) 6306.10 psi c) 3 018.05 psi d) 9 054.15 psi

Solution: $s_{min} = \dfrac{16T_{min}}{\pi D^3} = \dfrac{16(2000)}{\pi(1.5)^3} = 3018.05 \text{ psi}$ $s_{max} = \dfrac{16T_{max}}{\pi D^3} = \dfrac{16(6000)}{\pi(1.5)^3} = 9054.15 \text{ psi}$

$$s_m = \frac{s_{min} + s_{max}}{2} = \frac{3018.05 + 9054.15}{2} = 6036.10 \text{ psi}$$

97. In an open belt drive, the driving pulley is 450 mm in diameter and the driven pulley is 1000 mm in diameter. The belt is 300 mm wide and 10 mm thick. The coefficient of friction of the belt drive is 0.30 and the mass of the belt is 2.8 kg/m of belt length. Other data are as follows: center distance between shafts, 4 m; maximum allowable tensile stress on the belt, 1500 kPa; and speed of driving pulley, 900 rpm. Calculate the maximum power that can be transmitted, in kW.
a) 40.82 kW b) 42.80 kW c) 48.20 kW d) 28.40 kW

Solution: $P = \dfrac{\pi n_1 T_1}{30} = \left(\dfrac{\pi n}{30}\right)(F_t)\left(\dfrac{D_1}{2}\right)$ $\dfrac{F_1 - F_c}{F_2 - F_c} = e^{f\theta}$ $F_t = F_1 - F_2 = (F_1 - F_c)\left(\dfrac{e^{f\theta} - 1}{e^{f\theta}}\right)$

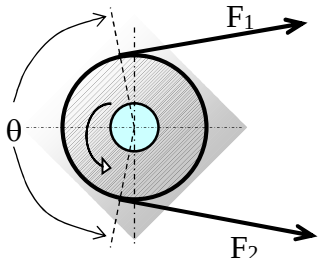
Belt speed, $V = \dfrac{\pi D_1 n_1}{60} = \dfrac{\pi(0.450)(900)}{60} = 21.21 \text{ m/s}$

Wrap angle, $\theta = \theta_1 = \pi - \left(\dfrac{D_2 - D_1}{C}\right) = \pi - \left(\dfrac{1000 - 450}{4000}\right) = 3.0041 \text{ radians}$

Belt tension ratio, $\dfrac{F_1 - F_c}{F_2 - F_c} = e^{f\theta} = e^{(0.30)(3.0041)} = 2.463$

Centrifugal Force, $F_c = \rho\,b\,t\,V^2 = \left(\dfrac{2.8 \text{ kg/m}}{b\,t}\right)(b\,t)(21.21 \text{ m/s})^2 = 1259.62 \text{ N}$

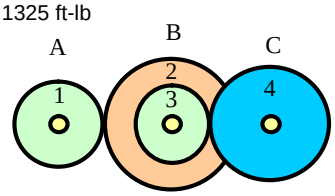
Maximum belt tension, $F_1 = s_t\,A = s_t\,b\,t = (1500\,000 \text{ N/m}^2)(0.30 \text{ m})(0.01 \text{ m}) = 4500 \text{ N}$



Belt Net Tension, $F_t = (F_1 - F_c)\left(\frac{e^{f\theta}-1}{e^{f\theta}}\right) = (4500 - 1259.62)\left(\frac{1.463}{2.463}\right) = 1924.76 \text{ N}$

Power to be transmitted, $P = \left(\frac{\pi n_1}{30}\right) F_t \left(\frac{D_1}{2}\right) = \left(\frac{\pi(900)}{30}\right)(1924.76)\left(\frac{0.45}{2}\right) = 40815.98 \text{ W} = 40.82 \text{ kW}$

98. There are three parallel shafts A, B, and C. Shaft A has 24 teeth gear of P_d = 4 meshing with a larger gear on shaft B having 70 teeth. A smaller gear, 20 teeth and pitch of 3, on shaft B meshes with 50 teeth gear on shaft C. Find the torque on shaft C if the input Hp to shaft A is 50 Hp turning at 1200 rpm, and the efficiency of each gear combination is 98 %.
a) 1532 ft-lb b) 1352 ft-lb c) 1253 ft-lb d) 1325 ft-lb



Solution: T_1 = 24 teeth T_2 = 70 teeth T_3 = 20 teeth T_4 = 50 teeth

$$\frac{n_1}{n_4} = \frac{T_2 \text{ x } T_4}{T_1 \text{ x } T_3} \qquad n_4 = n_1\left(\frac{T_1}{T_2}\right)\left(\frac{T_3}{T_4}\right) = (1200)\left(\frac{24}{70}\right)\left(\frac{20}{50}\right) = 164.57 \text{ rpm}$$

$$Hp_o = Hp(e) = (50)(0.98)(0.98) = 48.02 \qquad T_C = \frac{63000 Hp_o}{n_C} = \frac{(63\,000)(48.02)}{164.57} = 18\,382.82 \text{ in}\cdot\text{lb} = 1531.90 \text{ ft}\cdot\text{lb}$$

99. If a 450 kg flywheel rotates from 180 rpm to 168 rpm, how much energy, in N-m, it loss? Radius of the flywheel is 375 mm.
a) 1472.33 b) 1541.33 **c) 1451.33** d) 1433.51

Solution: $V_1 = 2\pi R N_1 / 60 = 2\pi(0.375)\left(\frac{180}{60}\right) = 7.069 \text{ m/s}$ $\quad V_2 = 2\pi R N_2 / 60 = 2\pi(0.375)\left(\frac{168}{60}\right) = 6.597 \text{ m/s}$

$$\Delta KE = \frac{m\left(V_1^2 - V_2^2\right)}{2} = \frac{450\left[(7.069)^2 - (6.597)^2\right]}{2} = 1451.33 \text{ N}\cdot\text{m}$$

100. A ¾ inch thick steel plate is to punch for a 1-in diameter hole every 10 sec. The actual punching takes 1 sec. The ultimate shear strength of the plate is 60,000 psi. The flywheel of the punch press has a mass moment of inertia of 500 in-lb-sec^2 and rotates at a mean speed of 150 rpm. What is the speed fluctuation, in rpm?
a) 65.4 rpm **b) 64.5 rpm** c) 6.749 rpm d) 67.49 rpm

Solution: $\Delta KE = \left(\frac{1}{2}\right) I\left(\omega_1^2 - \omega_1^2\right) = \left(\frac{1}{2}\right) I(\omega_1 - \omega_2)(\omega_1 + \omega_2) = I(\omega_1 - \omega_2)\left(\frac{\omega_1 + \omega_2}{2}\right) = I(\omega_1 - \omega)\omega$

Mean angular velocity, $\omega = \frac{2\pi N}{60} = \frac{2\pi(150)}{60} = 15.71 \text{ rad/s}$

Punching Force, $F = s_u(\pi dt) = (60\,000)(\pi)(1)(0.75) = 141371.67 \text{ lb}$

Kinetic Energy, $\Delta KE = \frac{1}{2}(F)t = \left(\frac{1}{2}\right)(141\,371.67)\left(\frac{0.75}{12}\right) = 4417.86 \text{ ft}\cdot\text{lb}$

Speed Fluctuation, $(\omega_1 - \omega_2) = \frac{\Delta KE}{I\omega} = \frac{(4417.86 \text{ ft}\cdot\text{lb})(12)}{(500 \text{ in}\cdot\text{lb}\cdot\text{s}^2)(15.71)} = 6.749 \text{ rad/s} = 64.5 \text{ rpm}$

101. A shaft, 1.5 inches in diameter, was loaded with a torque of 8,000 in-lb and a bending moment of 12,000 in-lb, determine the maximum shear stress induced on the shaft.
a) 21 763.5 psi b) 27 163.5 psi c) 23 761.5 psi d) 26 173.5 psi

Solution: $s_{s\,max} = \frac{16}{\pi D^3}\sqrt{M^2 + T^2} = \frac{16}{\pi(1.5)^3}\sqrt{(12\,000)^2 + (8\,000)^2} = 21\,763.5 \text{ psi}$

102. A solid coupling is used in a 75 mm shaft that transmits 300 kW power at 600 rpm. The coupling has 6 bolts and each 18 mm in diameter. Find the required bolt circle diameter if the bolt shearing stress is 27.5 MPa.
a) 227.4 mm b) 233.6 mm c) 254.5 mm d) 272.6 mm

Solution: $T = \frac{30\,P}{\pi\,n} = \frac{(30)(300)}{\pi(600)} = 4.775\ \text{kN}\cdot\text{m}$ $\qquad D_B = \frac{8T}{\pi\,d^2\,s_s\,n_B} = \frac{8(4\,775\,000\ \text{N}\cdot\text{mm})}{\pi(18\ \text{mm})^2(27.5\ \text{N/mm}^2)(6)} = 227.4\ \text{mm}$

103. A machinist is to cut a steel material with the following choices: both 1.5 inches diameter; high speed steel with recommended cutting speed of 90 fpm; carbide tipped with cutting speed of 300 fpm. Compute the rpm of the cutter.
a) 764 b) 376 c) 673 d) 746

Solution: $n = \frac{V}{\pi D} = \frac{300\ \text{fpm}}{\pi\left(\frac{1.5}{12}\ \text{ft}\right)} = 763.94\ \text{rpm}$

104. A centrifugal pump discharges 3000 liters per minute at a head of 10 meters. The pump is driven by a motor and pump efficiency is 68%. The pump rotates at 550 rpm. Find the torsional stress of shaft if shaft diameter is 35mm.
A. 13.85 MPa B. 11.85 MPa C. 12.85 MPa **D. 14.87 MPa**

Solution: $P = \frac{Q\cdot\gamma\cdot TDH}{e} = \frac{\left(\frac{3000}{60\times1000}\right)\text{m}^3/\text{s}\times9.81\text{kN/m}^3\times10\text{m}}{0.68} = 7.213\text{kW} = 7.213\times10^6\,\text{N}\cdot\text{mm/s}$

$$S_s = \frac{16\cdot T}{\pi\cdot D^3} = \frac{16\times\left(\frac{30\cdot P}{\pi\cdot N}\right)}{\pi\cdot D^3} = \frac{16\times\left(\frac{30\times\left(7.213\times10^6\right)}{\pi\times550}\right)}{\pi\times35^3} = 14.87\text{MPa}$$

105. A motor with gear ratio of 1.8 is used to drive a 800 mm diameter circular saw blade. The motor rotates at 1800 rpm. Compute for the peripheral speed of the blade.
A. 137.39 ft/sec B. 140.65 ft/sec C. 132.43 ft/sec D. 135.21 ft/sec

Solution $SR = \frac{N_{motor}}{N_{sawblade}}$; $N_{sawblade} = \frac{1800}{1.8} = 1000\text{rpm}$

$$V = \pi\cdot D\cdot N = \pi\times\frac{800}{1000}\text{m}\times\frac{1000}{60\text{sec}}\times3.28\text{ft/m} = 137.39\text{ft/sec}$$

106. A mechanical engineer wants a quick calculation on the shaft he will use. For a shaft length of 10 feet, find the diameter of the shaft that could safely deliver.
A. 1.18 in B. 7.55 in C. 2.34 in D. 1.64

Solution: $L = 8.95\cdot\sqrt[3]{D^2}$ $\qquad D = \sqrt{\left(\frac{10}{8.95}\right)^3} = 1.18\text{in}$

107. Two shafts, made of the same materials, are circular in construction. One is hollow and the other is solid. The hollow shaft inside diameter is one-half of the external diameter. The external diameter is equal to the diameter of the solid shaft. What is the ratio of the twisting moment of the hollow shaft to that of the solid shaft?
A.1/4 B. 1/3 C. 9/16 **D. 15/16**

Solution: $\theta_S\cdot D_S^4 = \theta_H\cdot\left(D_o^4 - D_i^4\right) = \frac{32\cdot T\cdot L}{\pi\cdot G}$ $\qquad$ But: $D_i = \frac{D_o}{2}$ and $D_s = D_o$

$$\theta_S\times D_o^4 = \theta_H\times\left[D_o^4 - \left(\frac{D_o}{2}\right)^4\right] \qquad \theta_S\times D_o^4 = \theta_H\times\left(D_o^4 - \frac{D_o^4}{16}\right) \qquad \theta_S\times D_o^4 = \theta_H\times\frac{15D_o^4}{16}$$

$$\theta_S = \frac{15}{16}\theta_H$$

108. A hollow shaft with an outside diameter of 100 mm is subjected to a maximum torque of 5,403.58 N.m. Determine its thickness if it not to exceed a shearing stress of 60 MPa or a twist of 0.5 degree per meter length of shaft. G=83,000 MPa.
A. 15 mm B. 86 mm C. 16.8 mm D. 14.2 mm

Solution: $\frac{\theta}{L}=\frac{32\cdot T}{\pi\cdot\left(D_o^4-D_i^4\right)\cdot G}$ $\qquad \frac{0.5^\circ\times\frac{\pi}{180^\circ}}{1\times1000}=\frac{32\times\left(5403.58\times10^3\right)}{\pi\times\left(100^4-D_i^4\right)\times83000}$ $\qquad D_i=70\text{mm}$

$$\text{then; } t=\frac{D_o-D_i}{2}=\frac{100-70}{2}=15\text{mm}$$

109. 90 kW of power is to be transmitted using a hollow shaft. It has an inner diameter of 30 mm and outside diameter of 42 mm. Determine the frequency of rotation of the shaft so that the shear stress cannot exceed 50 MPa.
A. 26.6 Hz B. 20.6 Hz C. 97.5 Hz D. 66.5 Hz

Solution: $T=\frac{P}{2\pi\cdot N}=\frac{90\times10^6}{2\cdot\pi\cdot N}=\frac{1432.3944\times10^4}{N}$ $\qquad$ Also, $T=\frac{S\cdot\pi\cdot\left(D_o^4-D_i^4\right)}{16D_0}$

Then, $\frac{1432.3944\times10^4}{N}=\frac{50\times\pi\times\left(42^4-30^4\right)}{16\times42}$ $\qquad N=26.6\frac{\text{rev}}{\text{s}}=26.6\frac{\text{cycle}}{\text{sec}}=26.6\text{Hz}$

110. A hollow shaft is to substitute a solid shaft with the same material and same torsional strength. The hollow shaft should be half the weight of the solid one. If the solid shaft diameter is 3.5 inches, find the outside diameter and the inside diameter of the shaft in millimeters.
A. 107.31 mm ; 86.97 mm B. 112.231 mm ; 84.60 mm C. 120.217 mm; 65.97 mm D. 131.204 mm ; 54.30 mm

Solution: When solid shaft is to be replaced by hollow shaft having equal strength but 1/2 weight $\qquad D_s=3.5\text{in}=88.9\text{mm}$

$$D_o=\left(\frac{1+\sqrt{2}}{2}\right)\cdot D_s=\left(\frac{1+\sqrt{2}}{2}\right)\times88.9=107.31\text{mm} \qquad D_i=\sqrt{D_o^2-\frac{D_s^2}{2}}=\sqrt{107.31^2-\frac{88.9^2}{2}}=86.97\text{mm}$$

111. A flange bolt coupling connects a turbine to a generator with an output of 40 MW and rotates at 3600 rpm. Generator efficiency is 90%. The coupling has a bolt circle diameter of 500 mm. If there are 16 bolts, determine the force acting on each bolt.
A. 26.41 kN **B. 29.47 kN** C. 35.62 kN D. 32.61 kN

Solution: $P_{input}=\frac{P_{output}}{e}=\frac{40}{0.90}=44.44\text{MW}$ $\qquad T=\frac{30P}{\pi N_m}=\frac{30\times\left(44.44\times10^3\right)}{\pi\times3600}=117.88\text{kN.m}$

$$F_b=\frac{2T}{n_bD_b}=\frac{2\times\left(117.88\times10^3\right)}{16\times500}=29.47\text{kN}$$

112. A solid coupling is used in a 75 mm shaft that transmits 300 kW power at 600 rpm. The coupling has 6 bolts and each 18 mm in diameter. Find the required bolt circle diameter if the bolt shearing stress is 27.5 MPa.
A. 227.4 mm B. 233.6 mm C. 254.5 mm D. 272.6 mm

Solution: $S_{sb}=\frac{8T}{\pi\cdot n_b\cdot d^2\cdot D_b}$ $\qquad$ and $\qquad T=\frac{30P}{\pi N}$ $\qquad$ Then, $D_b=\frac{8\left(\frac{30P}{\pi N}\right)}{\pi\cdot n_b\cdot d^2\cdot S_{sb}}=\frac{8\times\left[\frac{30\times\left(300\times10^6\right)}{\pi\times600}\right]}{\pi\times6\times18^2\times27.5}=227.4\text{mm}$

113. A 75 mm diameter shaft that transmits 150 kW at 400 rpm is designed with a flat key. If allowable shearing stress is 20 MPa and key width is 15 mm, determine the length of the key.
A. 30.65 mm **B. 31.83 mm** C. 33.75 mm D. 32.85 mm

Solution: $L=\frac{2T}{S_c\cdot b\cdot D}=\frac{2\left(\frac{30P}{\pi N}\right)}{S_c\cdot b\cdot D}=\frac{2\times\left[\frac{30\times\left(150\times10^6\right)}{\pi\times4000}\right]}{20\times75\times15}=31.83\text{mm}$

114. A square key is to be used in a 40 mm flat key and that will develop a 2 kN.m torque. If bearing stress of key is 448 MPa, determine the cross sectional dimension of flat key to be used using key length of 21.12 mm.
A. 21.12 mm B. 25.61 mm C. 28.21 mm D. 18.61 mm

Solution: $t = \frac{4T}{S_c \cdot b \cdot D} = \frac{4 \times \left(2 \times 10^6\right)}{448 \times 21.12 \times 40} = 21.13\text{mm}$

115. A line shaft, transmits 7.46 kW at a speed of 1200 rpm, is designed with a rectangular key. If the shearing stress for the shaft and key are 30 N/mm^2 and 40 N/mm^2, respectively. What is the diameter of the shaft?
A. 18.7 mm **B. 21.7 mm** C. 25.8 mm D. 30.2 mm

Solution: $S = \frac{16T}{\pi \cdot D^3} = \frac{16\left(\frac{30P}{\pi \cdot N}\right)}{\pi \cdot D^3}$ hence; $D = \sqrt[3]{\frac{16\left(\frac{30P}{\pi \cdot N}\right)}{\pi \cdot S}} = \sqrt[3]{\frac{16\left[\frac{30 \times \left(7.46 \times 10^6\right)}{\pi \times 1200}\right]}{\pi \times 30}} = 21.6\text{mm}$

116. A load of 5000 kg is supported by a bearing with 150 mm diameter and 300 mm long. If coefficient of friction is 0.18, find the torque required to rotate the shaft.
A. 331 N-m **B. 662 N-m** C. 873 N-m D. 1020 N-m

Solution: $F_f = f \cdot W = 0.18 \times \left(5000 \times 9.8066\right) = 8825.94\text{N}$ $T_f = F_f \cdot \frac{D}{2} = 8825.94 \times \frac{0.150}{2} = 662\text{N.m}$

117. A shaft, rotates at 500 rpm, is supported by a bearing with frictional loss of 15 kW. The bearing load is 30 kN and friction of 0.14. Find the bearing diameter.
A. 136.42 mm B. 146.42 mm C. 156.42 mm D. 166.42 mm

Solution: $F_f = f \cdot W = 0.14 \times 30 = 4.2\text{kN}$ $P_f = 2\pi \cdot T_f \cdot N = 2\pi \cdot \left(F_f \times \frac{D}{2}\right) \cdot N = \pi \cdot F_f \cdot D \cdot N$

Then, $D = \frac{P_f}{\pi \cdot F_f \cdot N} = \frac{15}{\pi \times 4.2 \times \frac{500}{60}} \times 1000 = 136.42\text{mm}$

118. A shaft, rotates at 1740 rpm, is supported by a bearing with a length of 105 mm and diameter of 64 mm. If the load is light and SAE Oil No. 20 (μ = 2.4 x 10^{-6} reyns) is used and diametral clearance is 0.136 mm, find the power loss due to friction.
A. 164 watts **B. 174 watts** C. 184 watts D. 194 watts

Solution: μ = 2.4 x 10^{-6} reyns = 0.0165 Pa-s $h = C_d / 2 = 0.136/2 = 0.068$ mm

Then, $T_f = \frac{4 \cdot \pi^2 \cdot r^3 \cdot \mu \cdot L \cdot N_s}{h} = \frac{4 \times \pi^2 \times \left(\frac{0.064}{2}\right)^3 \times 0.0165 \times 0.105 \times \frac{1740}{60}}{0.068 \times 10^{-3}} = 0.9558\text{N.m}$

$P_f = 2 \cdot \pi \cdot T_f \cdot N_s = 2 \times \pi \times 0.9558 \times \frac{1740}{60} = 174\text{watts}$

119. A bearing operates satisfactorily with a diametral clearance of 0.0028 inches supports a journal running at 1200 rpm. The bearing is 2.085 inches in diameter and 1.762 in long. It supports a total radial load of 1400 lbs. at 160° F operating temperature of the oil film, the bearing modulus Zn/P was found to be 16.48. Determine the bearing stress.
A. 281 psi **B. 381 psi** C. 481 psi D. 581 psi

Solution: $S_b = \frac{F}{A} = \frac{F}{D \times L} = \frac{1400}{2.085 \times 1.762} = 381\text{psi}$

120. Find the tooth thickness of a 14° involute gear having a diametral pitch of 6.
A. 5.33 mm **B. 6.65 mm** C. 8.45 mm D. 12.36 mm

Solution: $\text{tooth thickness} = \frac{1.5708}{P_d} = \frac{1.5708}{6} \times 25.4 = 6.65\text{mm}$

121. Compute for the speed mounted in a 52.5 mm diameter shaft receiving power from a prime motor with 250 Hp.
A. 2182 rpm B. 2081 rpm **C. 2265 rpm** D. 2341 rpm

Solution: $P = \frac{D^3 \times N}{80}$ hence; $N = \frac{80P}{D^3} = \frac{80 \times 250}{\left(\frac{52.5}{25.4}\right)^3} = 2265\text{rpm}$

122. A spur pinion rotates at 1800 rpm and transmits to mating gear 30 Hp. If the pitch diameter is 8 inches and the pressure angle is 14.5°, determine the total loads in lbs.
A. 123.45 lbs B. 653.15 lbs **C. 271.14 lbs** D. 327.43 lbs

Solution: $T = \frac{63{,}000Hp}{N_m} = \frac{63{,}000 \times 30}{1800} = 1050 in.lb$ $F_t = \frac{2T}{D} = \frac{2 \times 1050}{8} = 262.5 lbs$

Then; $F = \frac{F_t}{\cos\phi} = \frac{262.5}{\cos 14.5} = 271.14 lbs$

123. A precision cut gear in an intermittent service transmits 25 Hp at a pitch line velocity of 6000 ft/min. Compute for the dynamic load.
A. 244 lb B. 264 lb **C. 274 lb** D. 284 lb

Solution: $F_t = \frac{Hp \times 33000}{V_m} = \frac{25 \times 33000}{6000} = 137.5 lbs$

For precision cut; $F_d = \left[\frac{78 + \sqrt{V_m}}{78}\right] \times F_t = \left[\frac{78 + \sqrt{6000}}{78}\right] \times 137.5 = 274 lbs$

124. A helical gear having 28 teeth and pitch diameter of 7 has a helix angle of 22 degrees. Find the circular pitch in a plane normal to the pitch.
A. 0.528 B. 0.628 **C. 0.728** D. 0.828

Solution: $P_{cn} = \left(\frac{\pi D}{T}\right) \times \cos\psi = \left(\frac{\pi \times 7}{28}\right) \times \cos 22 = 0.728$

125. A 20-tooth helical gear has a pitch diameter of 5 inches. Find the normal diametral pitch if helix angle is 22 degrees.
A. 3.31 in **B. 4.31 in** C. 5.31 in D. 6.31 in

Solution: $P_{dn} = \frac{T}{D \times \cos\psi} = \frac{20}{5 \times \cos 22} = 4.31 \text{ in}$

126. A helical gear with a tangential load of 200 lbs has an axial load f 73 lbs. Find the helix angle.
A. 14 degrees B. 16 degrees C. 18 degrees **D. 20 degrees**

Solution: $\psi = \tan^{-1}\left[\frac{F_a}{F_t}\right] = \tan^{-1}\left[\frac{73}{200}\right] = 20^\circ$

127. In a pair of gear that connects a pair of shaft at 90°, the velocity ratio is 3 to 1. If the gear is straight bevel, what is the cone pitch angle of smaller gear?
A. 71.57 deg B. 65.34 deg **C. 18.43 deg** D. 12.34 deg

Solution: $SR = \frac{T_g}{T_p} = \frac{3}{1}$ $\tan\alpha = \frac{\sin\theta}{\frac{T_g}{T_p} + \cos\theta}$ For θ = 90°, $\alpha = \tan^{-1}\left[\frac{T_p}{T_g}\right] = \tan^{-1}\left[\frac{1}{3}\right] = 18.43 \text{ deg}$

128. A left hand spiral bevel pinion rotates clockwise and transmits power to a mating gear with speed ration of 2 to 1. Calculate the pitch angle of the pinion.
A. 16.56 deg B. 20.56 deg **C. 26.56 deg** D. 32.56 deg

Solution: $\alpha = \tan^{-1}\left[\frac{1}{SR}\right] = \tan^{-1}\left[\frac{1}{2}\right] = 26.56 \text{ deg}$

129. A gear has a cone angle of 65° while the pinion has 25°. Find the speed ratio.
A. 1.5 B. 5.2 C. 4.23 **D. 2.14**

Solution: $SR = \frac{\sin\beta}{\sin\alpha} = \frac{\sin 65}{\sin 25} = 2.14$

130. A work at 1150 rpm drives a worm gear. The velocity is 15 to 1. A 10 hp motor is used to supply the worm with pitch gear diameter of 3 in. Find the force on the worm.
A. 365.37 lbs B. 465.37 lbs. C. 565.37 lbs D. 665.37 lbs

Solution: $F_t = \frac{2T}{D} = \frac{2}{D}\left(\frac{63{,}000Hp}{N_m}\right) = \frac{2}{3}\left(\frac{63{,}000\times 10}{1150}\right) = 365.21\text{lbs}$

131. A double thread worm has normal pressure angle of 14.5, a pitch diameter of 3.5 in and a lead of 1.5 in. Find the pressure angle of the worm.
A. 11.68° B. 12.68° C. 13.68° **D. 14.68°**

Solution: $\lambda = \tan^{-1}\left(\frac{L}{\pi D_w}\right) = \tan^{-1}\left(\frac{1.5}{\pi\times 3.5}\right) = 7.768^\circ$ Then; $\phi = \tan^{-1}\left(\frac{\tan\phi_n}{\cos\lambda}\right) = \tan^{-1}\left(\frac{\tan 14.5}{\cos 7.768}\right) = 14.628^\circ$

132. A belt drive uses pulleys with center distance of 72 inches. If the pulley diameters are 6 in. and 12 in., respectively, find the angle of contact on the small pulley.
A. 180.60 deg B. 243.40 deg C. 203.61 deg **D. 175.22 deg**

Solution: $\theta = \pi - \frac{D_2 - D_1}{C} = \pi - \frac{12-6}{72} = 3.0582\text{rad}\times\frac{180^\circ}{\pi\text{rad}} = 175.22^\circ$

133. An open belt drive uses pulleys with center distance of 72 cm. If the pulley diameters are 6 cm and 12 cm, respectively, determine the belt length.
A. 172.39 cm B. 160.39 cm C. 184.39 cm D. 190.39 cm

Solution: $L = \frac{\pi}{2}(D_1 + D_2) + 2C + \frac{(D_2 - D_1)^2}{4C} = \frac{\pi}{2}(6+12) + 2(72) + \frac{(12-6)^2}{4(72)} = 172.39\text{cm}$

134. A belt, with specific weight of 0.035 lb/in^3, is 3/8-inch thick and 12-inch wide. It is used on 24 inches diameter pulley rotating at 600 rpm. If the angle of contact is 150 degrees, the coefficient of friction is 0.3 and stress is 300 psi, how much power can it deliver?
A. 65.4 Hp **B. 69.5 Hp** C. 60.5 Hp D. 63.5 Hp

Solution: $F_1 = S\cdot b\cdot t = 300\times\frac{3}{8}\times 12 = 1350\text{lbs}$; $V_s = \pi\cdot D\cdot N = \pi\times\frac{24}{12}\times\frac{600}{60} = 62.83\text{fps}$

$$F_c = \frac{12\cdot\rho\cdot b\cdot t\cdot V_s^2}{g} = \frac{12\times 0.035\times\frac{3}{8}\times 12\times 62.83^2}{32.2} = 231.707\text{lbs}$$

$$F = (F_1 - F_c)\left(\frac{e^{f\theta}-1}{e^{f\theta}}\right) = (1350 - 231.707)\left(\frac{e^{\left(0.3\times\frac{150\times\pi}{180}\right)}-1}{e^{\left(0.3\times\frac{150\times\pi}{180}\right)}}\right) = 608.42\text{lbs}$$

$$Hp = \frac{TN_m}{63{,}000} = \frac{N_m}{63{,}000}\left(\frac{F\cdot D}{2}\right) = \frac{600}{63{,}000}\left(\frac{608.42\times 24}{2}\right) = 69.5Hp$$

135. A 350 mm wide belt has an angle of contact of 160°. The working stress of belt is 2 MPa and coefficient of friction is 0.32. If the pulley has an effective belt pull of 3 kN, determine the thickness of the belt.
A. 6.42 mm **B. 7.24 mm** C. 8.68 mm D. 9.47 mm

Solution: $\frac{F_1}{F_2} = e^{f\theta} = e^{0.32\times\left(\frac{160\times\pi}{180}\right)} = 2.444$ therefore : $F_2 = \frac{F_1}{2.444}$

$F = F_1 - F_2$ substituting $3 = F_1 - \frac{F_1}{2.444}$ therefore ; F_1 = 5.07

Then; $t = \frac{F_1}{S\cdot b} = \frac{5.07\times 10^3}{2\times 350} = 7.24\text{mm}$

136. Determine the speed of the belt used in a pulley with belt pull of 2.5 kN and is driven by a 20 Hp motor.
A. 19.58 ft/sec B. 5.97 ft/sec C. 7.42 ft/sec D. 10.86 ft/sec

Solution: F = 2.5 kN ≈ 562.12 lbs

$$V_s = \frac{550Hp}{F} = \frac{550\times 20}{562.12} = 19.568\text{ft/sec}$$

137. A chain and sprocket has 18 teeth with chain pitch of ½ in. Find the pitch diameter of sprocket.
A. 0.879 in B. 1.879 in **C. 2.879 in** D. 3.879 in

Solution: $D = \dfrac{P}{\sin\left(\dfrac{180}{T}\right)} = \dfrac{0.5}{\sin\left(\dfrac{180}{18}\right)} = 2.879\text{in}$

138. A chain and sprocket has 24 teeth with chain pitch of ½ in. If the sprocket turns at 600 rpm, find the speed of chain.
A. 601.72 fpm B. 621.72 fpm C. 641.72 fpm D. 661.752 fpm

Solution: $V = \pi \cdot D \cdot N = \pi \times \dfrac{P}{\sin\left(\dfrac{180}{T}\right)} \times N = \pi \times \dfrac{0.5}{\sin\left(\dfrac{180}{24}\right) \times 12} \times 600 = 601.72\text{fpm}$

139. A chain and sprocket has a pitch diameter of 28.654 in and there are 90 teeth available. Find the pitch of the chain.
A. ½ in B. ¾ in **C. 1 in** D. 1 ¼ in

Solution: $P = D \times \sin\left(\dfrac{180}{T}\right) = 28.654 \times \sin\left(\dfrac{180}{90}\right) = 1\text{in}$

140. A spring deflects 8.5 inches if a load of 50 lb is applied. What load deflects the spring by 2.5 in?
A. 10.64 lb B. 12.48 lb C. 13.48 lb **D. 14.70 lb**

Solution: $k = \dfrac{F_{8.5}}{\delta} = \dfrac{50}{8.5} = 5.88\text{lb/in}$ then; $F_{2.5} = k \cdot \delta = 5.88 \times 2.5 = 14.70\text{lb}$

141. A 360 kg load is supported by four compression coil spring in parallel. Each spring has a gradient of 0.717 kg/mm. Calculate the deflection.
A. 125.52 mm B. 132.52 mm C. 138.52 mm D. 145.52 mm

Solution: $\delta = \dfrac{F}{4k} = \dfrac{360}{4(0.717)} = 125.52\text{mm}$

142. An UNC bolt has a stress area of 0.606 in^2. If it is to be made from a carbon steel material, what is the permissible working stress of the bolt?
A. 4055.5 psi B. 5244.5 psi C. 4675.5 psi D. 4186.5 psi

Solution: from Vallance; $S_w = C \times A_s^{0.418}$ where : C for carbon steel = 5000 and C for alloy steel = 15000

$S_w = 5000 \times 0.606^{0.418} = 4055.5\text{psi}$

143. The allowable working stress of a 1.5 inches bolt which is screwed up tightly in packed joint is 13000psi, determine the working strength.
A. 11,465.5 lbs B. 13,860.5 lbs **C. 11,212.5 lbs** D. 11,854.5 lbs

Solution: from Machinery Handbook, $F_w = S_t\left(0.55d^2 - 0.25d\right)$ $F_w = 13{,}000\left[0.55\left(1.5^2\right) - 0.25(1.5)\right] = 11{,}212.5\text{lbs}$

144. The power screw's linear speed is 7 ft/min and lead of 8 mm. If the total torque required to turn the power screw is 50 N.m, find the horsepower input of the power screw.
A. 2.86 Hp B. 1.84 Hp **C. 2.14 Hp** D. 2.38 Hp

Solution: $N_m = \dfrac{V_m}{L} = \dfrac{(8 \times 12 \times 25.4)}{8} = 304.8\text{rpm}$ $Hp = \dfrac{T \cdot N_m}{63000} = \dfrac{\left(50 \times \dfrac{39.36 \times 2.205}{9.8066}\right) \times 304.8}{63000} = 2.14\text{Hp}$

145. A double square thread power screw has a root diameter of 0.55 inches. If the screw has a pitch of 0.2 in., determine the major diameter.
A. 0.524 in **B. 0.750 in** C. 0.842 in D. 0.961 in

Solution: For square thread:

$h = \dfrac{p}{2} = \dfrac{0.2}{2} = 0.1$ then; $D_o = 2h + D_i = 2(0.1) + 0.55 = 0.750\text{in}$

146. Determine the lead angle of a square thread screw that has an efficiency of 70% when friction of threads is 0.10. Consider collar friction as negligible.
A. 12.6° **B. 14.3°** C. 16.5° D. 18.3°

Solution: For square thread power screw, neglecting the collar friction, $e = \frac{\tan\lambda(1 - f\tan\lambda)}{\tan\lambda + f} \times 100\%$

$0.70 = \frac{\tan\lambda(1 - 0.1\tan\lambda)}{\tan\lambda + 0.1} \times 100\%$ Therefore; λ = 14.3°

147. A block weighing 350 lbs is lifted by an SAE 1040 eyebolt. SAE 1040 material has a S_u = 67 ksi and S_y = 55 ksi. Calculate the stress area (in inches square) of the bolt if it is under the unified coarse series thread.
A. 1341 **B. 0.1134** C. 0.991 D. 1043

Solution: From Faires, $F_w = \frac{S_y}{6}(A_s)^{3/2}$ Then, $A_s = \sqrt[3]{\left(\frac{6 \cdot F_w}{S_y}\right)^2} = \sqrt[3]{\left(\frac{6 \times 350}{55{,}000}\right)^2} = 0.1134 \text{ in}^2$

148. The tension on the tight side of the brake is thrice as the slack side. If coefficient of friction is 0.25, find the angle of contact on the band.
A. 240.61 deg **B. 251.78 deg** C. 286.75 deg D. 275.65 deg

Solution: $\frac{F_1}{F_2} = e^{f \cdot \theta} = 3$ then; $\theta = \frac{\ln 3}{0.25} \times \frac{180}{\pi} = 251.78 \text{deg}$

149. The maximum tensile stress of a steel band is 55 MPa. The band has a thickness of 4 mm and has a tension of 6 kN in the tight side. Determine the width of band that should be used.
A. 25.25 mm **B. 27.27 mm** C. 28.28 mm D. 29.29 mm

Solution: $t = \frac{F_1}{S_t \cdot b} = \frac{6 \times 10^3}{55 \times 4} = 27.27 \text{mm}$

150. In a cone clutch, the angle of the conical elements is 10 degrees. The mean diameter of conical sections is 200 mm and an axial force of 600 N is applied. If a coefficient of friction of 0.45 is assumed, determine the torque that the cone clutch can transmits.
A. 135.49 N.m **B. 155.49 N.m** C. 175.49 N.m D. 195.49 N.m

Solution: $T_f = f \cdot \frac{Fa}{\sin\theta} \cdot \frac{D_m}{2} = 0.45 \times \frac{600}{\sin 10} \times \frac{0.200}{2} = 155.49 \text{N} \cdot \text{m}$

151. In a small LPG station, a spherical tank with an internal pressure of 5MPa has a thickness of 15 mm. The joint efficiency is 96% and stress is limited to 46875 kPa. Find the inner diameter of the tank.
A. 150 mm B. 510 mm C. 450 mm D. 540 mm

Solution: $Di = \frac{4 \cdot S_t \cdot t \cdot \eta}{Pi} = \frac{4 \times 46.875 \times 15 \times 0.96}{5} = 540 \text{mm}$

152. A 675 kg body moves at 24 kph. What is the kinetic energy of the body?
A. 13,000 N.m B. 14,000 N.m **C. 15,000 N.m** D. 16,000 N.m

Solution: $KE = \frac{1}{2} m \cdot V^2 = \frac{1}{2} \times 675 \times \left(\frac{24 \times 1000}{3600}\right)^2 = 15{,}000 \text{N} \cdot \text{m}$

153. If he force needed to move a mass weighing 56 lb along a horizontal surface is 20 lb, determine the coefficient of friction.
A. 0.01 B. 0.112 **C. 0.36** D. 0.28

Solution: $W = F_n$ and $f \cdot F_n = F$ therefore; $f = \frac{F}{F_n} = \frac{F}{W} = \frac{20}{56} = 0.36$

154. _____ is the process of shaving off small amounts of metal using hand-held tools. This process is most often done to obtain precision alignment of machine parts; it is also done to provide shallow pockets that will hold lubricants on flat surfaces, such as machine ways.
a) Drilling **b) Scraping** c) Reaming d) Milling

155. _____ means putting the parts of something together.
a) Laying out **b) Assembling** c) Installing d) Fabricating

156. _____ are tools used to turn, or drive, screws; made in may sizes and several shapes; the size is measured by the length of the blade, which is made of tool steel that is hardened and tempered. The screwdriver point for driving slotted screws should be correctly shaped; it must be fit the slot in the screw.
a) Wrenches b) Hammers **c) Screw drivers** d) Scrapers

157. A place in which metal parts are cut to the size required and put together to form mechanical units of machines, the machine so made to be used directly or indirectly in the production of the necessities and luxuries of civilization.
a. Welding shop b. Junk shop **c. Machine shop** c) Flower shop

158. A metal-turning machine tool in which the work, while revolving on a horizontal axis, is acted upon by a cutting tool which is made to move slowly (feed) in a direction more or less parallel to the axis of the work (longitudinal feed), or in a direction of right angles to the axis of work (cross feed).
a. Grinding machine b. B. Milling machine **c. Lathe machine** d. Drilling machine

159. This screw driver has a bent handle; it is used where a straight screwdriver will not reach.
a) Offset screw driver b) Phillips screw driver c) Mechanical screw driver d) Mill screw driver

160. A machine tool used mainly for producing holes in metal.
a. Reaming machine **b. Drill press** c. Welding machine d. Boring machine

161. _____ are tools used for cutting small wire and for holding, twisting, turning, pulling, and pushing.
a) Screw drivers b) Wrenches **c) Pliers** d) Hammers

162. A machine which is ordinarily used for finishing flat or partly curved surfaces of metal pieces few in number and not usually over a foot or too long.
a. Shaper machine b. Planer machine c. Milling machine d. Grinding machine

163. A machine tool in which an abrasive wheel is used as a cutting tool to obtain a very high degree of accuracy and a smooth finish on metal parts, including soft and hardened steel.
a. Drilling machine b. Milling machine **c. Grinding machine** d. Welding machine

164. A file which is thick, rectangular-shaped file with parallel edges.
a. Hand file b. Pillar file c. Mill file d. Half-moon file

165. A file which is tapered in thickness and of uniform width. This is used for filing slots and keyways.
a. Pillar file b. Hand file c. Mill file d. Half-moon file

166. _____ also known as combination pliers, are used for gripping; can also cut small-size wire; the slip-joint makes it possible to grip large parts.
a) Slip-joint pliers b) Side cutting pliers c) Round nose pliers d) Long nose pliers

167. Which of the following is not belong to standard shapes of file?
a. flat b. half-round c. three-square **d. none of these**

168. One of the three basic ways of using a file which is done by pushing the file lengthwise, straight with or slightly diagonal to the workpiece.
a. Lathe filing b. Draw filing **c. Straight filing** d. Back filing

169. One of the three basic ways of using a file which consists of stroking the file against the revolving workpiece held in the lathe.
a. Lathe filing b. Straight filing c. Draw filing d. Mill filing

170. One of the three basic ways of using a file which is performed by grasping the file at end and pushing and drawing across the workpiece.
a. Draw filing b. Lathe filing c. Straight filing d. None of the above

171. A hand tool which is commonly used for cutting or twisting wire and chipping small parts and not to be used for tightening or loosening bolts and nuts.
a. Screwdriver b. Wrench **c. Pliers** d. None of the above

172. A type of pliers which is used for cutting wires and holding flat round stock.
a. Long-nose pliers b. Side-cutting pliers **c. Slip joint combination pliers or mechanical pliers** d. Square pliers

173. A type of pliers which is used in electrical works for cutting heavy or light wires or for cutting small nails.
a. Side-cutting pliers b. Long-nose pliers c. Mechanical pliers d. None of the above

174. A type of pliers which is used for cutting and holding fine wire. This is also useful in reaching tight places.
a. Long-nose pliers b. Slide-cutting pliers c. Diagonal pliers d. None of the above

175. Which of the following is a primary forming process?
a) Casting b) Turning c) Fitting d) Buffing

176. Which of the following is not a machining process?
a) Turning b) Milling **c) Casting** d) Grinding

177. The joints produced by this method are as strong as the parent metal.
a) Soldering b) Brazing c) Riveting **d) Welding**

178. Which one of the following is a finishing process?
a) Rolling b) Forging **c) Sintering** d) Engraving

179. Which of the following process affects the changes in properties of materials?
a) Shaping **b) Hardening** c) Sintering d) Anodizing

180. The system used for mass production of identical parts within specified limits of sizes for selection of components at random is known as:
a) Simplification b) Standardization **c) Interchangeable system** d) Automation

181. Alloys are extensively used in industry because they are:
a) Sufficiently soft **b) Have good strength** c) Malleable d) Ductile

182. Which of the following is the most abundantly used material in industry?

a) Cast iron **b) Mild steel** c) Medium carbon steel d) High carbon steel

183. Wrought iron contains a maximum of which of the following?
a) 0.01 % carbon b) 0.3 % carbon c) 0.6 % carbon d) 2.0 % carbon

184. Pig iron is produced by reduction of iron ore in a:
a) Cupola b) Bessemer converter c) Open hearth furnace **d) Blast furnace**

185. Which of the following are the main alloying elements present in stainless steel?
a) Nickel and manganese b) Nickel and tungsten **c) Nickel and chromium** d) Nickel and cobalt

186. Along with chromium and vanadium the main constituent of high speed steel is which of the following?
a) Manganese b) Nickel **c) Tungsten** d) Vanadium

187. Grey cast iron gives grey fracture due to the presence of which of the following?
a) Ferrite b) Pearlite **c) Graphite** d) Cementite

188. Copper is the parent metal of brass. Which of the following is the other metal present in brass?
a) Lead b) Tin c) Aluminum **d) Zinc**

189. Gun metal contains 5 to 10 percent of which of the following materials?
a) Zinc b) Lead **c) Tin** d) Aluminum

190. Y-alloy is an alloy of aluminum and which of the following metals?
a) Manganese b) Iron c) Tin **d) Copper**

191. Inconel contains 80 % nickel and 14 % chromium. The other metal present in inconel is:
a) Iron b) Vanadium c) Silver d) Tin

192. Monel contains mainly with traces of iron and manganese. The main alloying element of monel is:
a) Aluminum **b) Copper** c) Zinc d) Lead

193. Bearing materials should posses which of the following?
a) High tensile strength b) High hardness c) Hard core **d) High compressive strength**

194. Which of the following is the trade name of polypropylene?
a) Alkane b) Polyprex **c) Styrene** d) Durite

195. The following instrument can be used for subscribing lines parallel to the edges of a part:
a) Vernier caliper b) Ordinary scale **c) Hermaphordite caliper** d) Combination set

196. Which of the following is the use of surface gauge?
a) Laying out the work accuracy b) Check flatness of surface c) Checking surface finish d) Leveling the machine tools

197. The thickness of a thin sheet can be accurately checked with the help of:
a) Ordinary scale **b) Micrometer** c) Combination set d) Caliper

198. V-block is used in mechanical engineering workshop to check which of the following?
a) Straightness of the job b) Taper on a job c) Height of a job **d) Cylindrical jobs**

199. _____ is a strong tool used for general work in the shop. Its jaws are pointed at such an angle that it can be used in close corners and unhandy places.
a) Adjustable-end wrench b) Adjustable S-wrench c) Monkey wrench d) Vise-grip wrench

200. A sine bar is specified by:
a) Its total length b) Diameter of the rollers c) Its weight **d) Center to center distance between the rollers**

201. _____ is a handy tool. It works in close places and the strong steel jaws lock to the work and will not slip; it acts like a vise, clamp, plier, pipe wrench, open-end wrench, or locking tool.
a) Adjustable-end wrench b) Adjustable S-wrench c) Monkey wrench **d) Vise-grip wrench**

202. A ratchet screw is provided on a micrometer screw gauge to:
a) Lock the measured reading **b) maintain constant measuring pressure for all readings**
c) Prevent wearing of screw threads d) Allow zero adjustments

203. _____ is a machine for pressing parts of machinery together or forcing them apart, such as pressing a shaft in or out of a pulley or gear
a) Arbor press b) Drill press c) Milling machine d) Forging machine

204. Adjusting nut is provided on a micrometer screw gauge to:
a) Allow zero adjustment **b) Compensate for wear and tear between screw and nut**
c) Eliminate backlash d) Maintain constant measuring pressure for all readings

205. External taper of a job can be measured accurately with help of:

a) Sine bar and slip gauges b) Sine bar and dial indicator
c) Dial indicator and slip gauges d) Slip gauges and vernier caliper

206. Internal dovetail taper can be measured by which of the following?
a) Sine bar and slip gauges b) Balls of standard size and dial indicator
c) Balls of standard size and sine bar **d) Balls of standard size and slip gauges**

207. Combination set is used to:
a) Measure long distances b) Measure cylindrical sizes of a length **c) Measure angles** d) Measure corner radius

208. _____ are made in many sizes and types are widely used in special work holding fixtures.
a) Toggle clamps b) C-clamps c) Spring clamps d) Spring clamps

209. It is a typical of material used for cylinder block.
a) Forged steel b) Drop-forged, heat-treated steel\
c) Cast iron and coated with chrome or molybde**num** **d) Cast iron**

210. Which of the following is a material used for a piston ring?
a) Forged steel b) Drop-forged, heat-treated steel\
c) Cast iron and coated with chrome or molybdenum d) Cast iron

211. Which of the following is the typical material used for an engine crank shaft?
a) Forged steel b) Heat-treated steel c) Cast iron d) Wrought iron

212. What is the function of a governor?
a) Store energy and give up whatever needed b) Regulate the speed during one cycle of a prime mover
c) Increase variation of speed **d) Adjust variation of speed by varying the input to the engine**

213. What is a machine used in testing steel generally strike the specimen with energy from 220 to 265 ft-lb?
a) Izod test **b) Charpy test** c) Rockwell test d) Test blocked

214. Almost always the soldering materials are a combination of which of the following alloys?
a) Lead and tin b) Tin and antimony c) Lead and antimony d) Both a, b & c

215. To ensure an adequate factor of safety in the design of a shaft with standard keyway, the key width should be about:
a) One half of the shaft diameter b) **One fourth of the shaft diameter**
c) One eighth of the shaft diameter d) One third of the shaft diameter

216. This is defined as the cutting time to reach a predetermined wear, called the tool wear criterion.
a) Wear duration b) Cycle time c) **Tool life** d) Life cycle

217. Machining operations with the proper application of a cutting fluid generally has the following attributes except:
a) Higher cutting speeds b) Higher feed rates c) Lengthened tool life d) H**igher cutting accuracy**

218. A material of construction (only developed commercially in the late 1940's concurrently with zirconium) offers the unique combination of wide ranging corrosion resistance, low density, and high strength.
a) Tungsten b) **Titanium** c) Vanadium d) Molybdenum

219. Which of the following is the lightest of all structural metals?
a) Aluminum b) Copper c) **Magnesium** d) Manganese

220. This is a type of welding whereby a wire or powder from the nozzle of a spray gun is fused by a gas flame, arc or plasma jet and the molten particles are projected in a form of spray by means of compressed air or gas. How do you call this type of welding?
a) Metal spray welding b) Electro-slug welding c) Electro-beam welding d) plasma arc welding

221. Which of the following does not belong to foundry or metal casting shop?
a) Core-making machine **b) Forging machine** c) Shake-out machine d) Molding machine

222. Which of the following is a suitable method to check the eccentricity of a shaft?
a) Bench target and scriber b) Bench top and tachometer c) Bench side and calliper **d) Bench centers and dial indicator**

223. This is a work supporting device which is bolted to the saddle of the lathe machine. It travels with the cutting tool, and used to prevent the springing away of the work piece from cutting tool. How do you call this part?
a) Tool post b) Carriage stop **c) Follower rest** d) Rubber-flex collets

224. Which of the following raw materials are used in the foundry molding operation?
a) Silica sand, linseed oil, & flour b) Silica sand, paste, & graphite electrode
c) Silica sand, lime, flour **d) Silica sand, bentonite, flour/paste, and water**

225. Which of the following is not part of a micrometer calliper?
a) Head screw b) Thimble c) Spindle d) Anvil

226. The flux that should be avoided in soldering electrical connection or commutator wires as it tends to corrode the connections.
a) Acid fluxes b) Salt ammoniac c) Zinc chloride d) Sodium chloride

227. It is a lathe machine operation used to produce a flat surface at the end of the part such as parts that are attached to other components, or to produce grooves for o-ring seats.
a) Boring b) Knurling **c) Facing** d) Parting

228. The most important operations in manufacturing is hole making. This can be done by which of the following?
a) Drilling machine b) Sawing machine c) Boring mills d) Milling machine
229. It is a machine operation used to produce regularly shaped, roughness on cylindrical surfaces, as in making knobs. How do you call this operation?
a) Milling b) Sawing c) Drilling **d) Knurling**
230. Which of the following material properties is adversely affected by grain refinement?
a) Creep resistance b) Tensile strength c) Ductility d) yield strength
231. Hard solder is made of which of the following?
a) Tin and zinc b) tin and copper **c) Copper and zinc** d) Tin and lead
232. Which of the following is the unit of mass moment of inertia?
a) kg-m^2 b) kg/m^2 c) kg d) N-m
233. Which of the following is the unit of Young's modulus of elasticity?
a) Dimensionless **b) Pascal** c) Metter d) Newton
234. When a lathe tool bit burns, it means that the:
a) Speed is too low b) Material is too hard **c) Speed is too fast** d) Material can't be cut
235. The area of the machine shop whose metal is being melted to form a new shape.
a) Foundry area b) Tool and die c) Welding area d) Mass production area
236. A corrosion occurs within or adjacent to a crevice formed by contact with another piece of the same or another metal.
a) Pitting **b) Galvanic** c) Erosion d) Crevice
237. Which of the following is not part of a headstock?
a) Anvil b) Spindle c) Motor d) Back gear
238. It refers to any layer or deposit of extraneous material on a heat-transfer surface.
a) Low line b) Pressure drop **c) Fouling** d) Scaling
239. Have the same thermal and minimum film thickness limitation as sleeve bearing.
a) Ball bearing b) Roller bearing **c) Thrust bearing** d) Oil whip
240. An oil storage tank roof formed to approximately a spherical surface, supported only at its periphery.
a) Self-supporting umbrella roof b) Self-supporting cone roof
c) Self-supporting d) Supported cone roof
241. What is a unit deformation?
a) Torsion **b) Strain** c) Stress d) Shear
242. Accident prevention is:
a) An association of employers, organization & individuals b) A job of a safety director
c) The Foreman's responsibility just as much as production d) The responsibility of top management
243. Alloy steel known for its resistance to corrosion, abrasion and wear that is usually ideal for mill grinding of ore in cement and concentrator application. It is usually combined with molybdenum to increase the depth hardening.
a) Manganese chromium steel **b) Chromium-moly steel** c) Chrome-nickel-moly steel d) Manganese-moly steel
244. Cutting of internal threads of a work piece can be produced by which of the following?
a) Milling **b) Tapping** c) Boring d) Reaming
245. Which of the following milling operations is used to produce curved profiles, with cutters that have specially shaped teeth?
a) Form b) Straddle c) End d) Slab
246. In screw threads, what is a pitch?
a) The distance from a point on one thread to a corresponding point on the next thread measured parallel to the axis.
b) The distance of the full length of the thread
c) The distance from the bottom of a head on a bolt to the first thread.
d) The distance from the top of one thread to the bottom of the next thread
247. Tapered shanks are used on large drill presses so that:
a) The drill can be centered more easily **b) The drill can be easily forced out of the sleeve with a drift**
c) The shank will not turn when cutting d) The shank can be ground when wrn

248. It is a type of chuck wherein a work piece with standard diameter or size could be attached fast and quick specially small size work of mass production. How do you call this type of chuck?
a) Collet attachment b) Lathe drive plate c) Clamp toe dog d) Steady center rest
249. A type of projection where the object is drawn as viewed in a glass box. Thus, the views are projected to six sides of the box.
a) Fourth angle projection **b) Third angle projection** c) Second angle projection d) First angle projection
250. Which of the following is often called as the backbone of lathe machine?
a) Bed b) Headstock c) Tailstock d) Carriage
251. Which of the following properties of metal is insensitive to the microstructure?
a) Hardness b) Ductility c) Tensile strength **d) Modulus of elasticity**
252. Which of the following elastic modulus is applied to liquids?
a) Young's Modulus **b) Bulk Modulus** c) Shear modulus d) Modulus of rigidity
253. Polymers which, at room temperature, can undergo large deformations under a load and return back to their original shape upon release of load called as:
a) Meso-polymers b) Thermoplastics c) Thermosetting polymers **d) Elastomers**
254. When using a drill press, the work should be held with which of the following?
a) The hand b) The glove hand c) Pliers **d) A vise and clamp**
255. Which of the following classes of materials exhibits a decreasing electrical conductivity with increasing temperature?
a) Intrinsic semiconductor b) P-type semiconductor **c) Metals** d) Pure ionic materials
256. Which of the following is another name of hydrochloric acid?
a) Sulfuric acid b) Acetic acid **c) Muriatic acid** d) Nitric acid
257. Fatigue failure occurs when a part is subjected to which of the following?
a) Fluctuating stress b) Torsion c) Tensile stress **d) Compressive stress**
258. A body having identical properties all over is called as:
a) Elastic **b) Homogeneous** c) Ductile d) Isentropic
259. If a material recovers its original dimensions when the load is removed, the material is said to be:
a) Annealed b) Brittle **c) Elastic** d) Plastic

260. It is the behaviour of metals where in strength is increased and ductility is decreased on heating at a relatively low temperature after cold working.
a) Strain aging b) Screw dislocation c) Clustering d) Twinning

261. A ductile fracture is characterized by which of the following?
a) Fragmentation into more than two pieces b) Negligible deformation
c) Appreciable plastic deformation prior to propagation of crack d) rapid rate for crank propagation

262. How do you call the ability of a material to absorb energy when deformed elastically and to return it when unloaded?
a) Resilience b) Hardness c) Fatigue strength d) Creep

263. The machinability of steel can be increased by which of the following?
a) Sulphur and carbon **b) Phosphorous, lead, & sulphur** c) Sulphur, graphite and aluminium d) Silicon and Sulphur

264. Which of the following is steel with 0.8 % carbon and 100 % pearlite?
a) Solidus b) hyper-eutectoid **c) Eutectoid** d) Austenite

265. The maximum hardenability of any steel depends on which of the following?
a) Chemical composition **b) Carbon content** c) Grain size d) Alloying element present

266. Hastalloy contains which of the following?
a) Nickel and molybdenum b) Nickel and copper c) Copper and aluminium d) nickel and aluminum

267. Trimming is a process associated with which of the following?
a) Machining of metals b) Press work c) Electroplating **d) Forging**

268. Addition of lead and bismuth to aluminium results in which of the following?
a) Improving machinability b) One of the best known age and precipitation hardening system
c) Improvement of corrosion resistance d) Improvement of casting characteristics

269. Which of the following does not pertain to joining of metals?
a) Welding b) Soldering c**) Casting** d) Brazing

270. Endurance strength is nearly proportional to the ultimate strength but not with:
a) Yield strength b) Design stress c) Shear stress d) b and c

271. If the velocity of a mass is the same all the time during which motion takes place is called:
a) Deceleration **b) Uniform motion** c) Acceleration d) None of these

272. In involute teeth, the pressure angle is often defined as the angle between the line of action and the line of tangent to the pitch circle. It is termed as:
a) Helix angle b) Angle of recess **c) Angle of obliquity** d) Arc of action

273. The function of the clutch in the machine tools is:
a) Lowering the drive speed **b) To disconnect or connect the shaft at will the drive**
c) Alignment of drive shaft d) To insure that two shafts line up at high speed

274. Which of the following is not a heat treatment process?
a) Sintering b) Annealing c) Hardening d) Tempering

275. An instrument used to analyse the compositions of metals:
a) Spectrometer b) Radiometer c) Profilometer d) Ultimate analyser

276. Creep is the term used in referring to the:
a) Elongation before yield point b) Maximum stress of brittle materials
c) Fatigue limit of ductile materials **d) Continuous increase in the strain, or deformation, of any material subjected to stress**

277. The strength of non-ferrous alloys is maximum at room temperature while that of ferrous metal has a maximum strength at:
a) 400 ºF b) 450 ºF c) 1200 ºF d) 350 ºF

278. Which of the following is not a kind of a cast iron?
a) Malleable iron **b) Head iron** c) Gray iron d) White iron

279. The kind of center which is being attached and meshed to the tailstock spindle which is also static while the work is rotating is:
a) Dead center b) Live center c) Focal center d) Work center

280. Which process does not belong to the group?
a) Resistance welding b) Soldering **c) Hardening** d) Brazing

281. It is the maximum stress achieved in stress-strain diagram.
a) Yield Strength **b) Ultimate strength** c) Elastic strength d) Shear strength

282. A support where one end is pinned and other is roller-supported.
a) Simply supported beam b) Column c) Compound supported beam d) Simple beam

283. Functions used to evaluate shear and moment diagrams, especially when discontinuities, such as concentrated load or moment, exist.
a) Singularity functions b) Machine element functions c) Finite element functions d) Statistical Element functions

284. A condition where principal stresses exist while all other tensor elements are zero is known as:
a) Symmetrical tensor b) Bolt tensor c) Unsymmetrical tensor d) Beam tensor

285. The stress at time of fracture or rupture is called as:
a) Ultimate stress **b) Fracture stress** c) Yield stress d) Fatigue stress

286. It is the linear interpolation between densities of alloy concentration.
a) Rule of thumb b) Miner's rule **c) Rule of mixtures** d) Slide rule

287. Compounds of carbon and other elements forming long-chain molecules.
a) Polymers b) Ceramics c) Glasses d) Isotropic

288. The stress above which stress is no longer linearly proportional to strain.
a) Proportional limit b) Elastic limit c) Ultimate limit d) Yield limit

289. When a hot part is cooled suddenly by quenching, there is momentarily a high temperature gradient that induces a stress gradient. Some metal parts under certain conditions crack as a result. How do you call this phenomenon?
a**) Thermal-shock failure** b) Thermal fatigue c) Honing d) Quenching

290. It is the condition of a machine element when it is completely inoperable, cannot perform its intended function adequately, or is unreliable for continued safe use. What do you call this condition?
a) Fail-safe condition **b) Failure condition** c) Critical condition d) Salvage condition

291. 47. It is defined as the change in volume divided by the original volume.
a. linearly elastic b. camber **c. dilatation** d. partially elastic

292. Material that can sustain elongation greater than 5% before fracture is called:
a) Brittle **b. ductile** c. deformable d. rigid

293. The name given to a load whose value is constant over long time is:
a) Static load **b. Sustained load** c. Average load d. Axial load

294.

295. It is the peak of the stress-strain curve and sometimes simply called as tensile strength. How do you call this?
a) Yield strength **b) Ultimate tensile strength** c) Endurance strength d) Elastic strength

296. It is a synergistic collection of machine elements. It is synergistic because as a design it represents an idea or concept greater than the sum of the individual parts. How do you call this?
a) Synthesis b) Analysis **c) Mechanical system** d) Concurrent engineering

297. How do you call the ratio of stress and strain?
a) Modulus of rigidity b) Modulus of resilience **d) Modulus of elasticity** d) Modulus of stiffness

298. What is the philosophy of involving many disciplines from the beginning of a design effort and keeping them involved throughout product development?
a) Synthesis b) Design c) Mechanical system **d) Concurrent engineering**

299. It is one of the design stages that may be found desirable to use field experience as a basis for further improvement of the product. Since the final product is available, it often becomes the model for evaluation during this design process. This statge is not always used in the design process. How do you call this?
a) Detail stage **b) Revision stage** c) Preliminary stage d) Feasibility stage

300. That portion of the stress-strain diagram where there is a large increase in strain with little or no increase in stress is called as:
a) Yield strength b) Ultimate tensile strength c) Endurance strength d) Elastic strength

301. This is the first stage of design processes that determines whether it is both possible and profitable to undertake a given engineering project. The ideas generated during this stage of the design process generally consist of general statements about overall concepts rather than specific descriptions of hardware. How do you call this?
a) Detail stage b) Revision stage c) Preliminary stage **d) Feasibility stage**

302. At this point in the stress-strain curve, the material experiences some amount of plastic strain and thus will not return to its original shape after release of the load.
a) Elastic limit b) Proportional limit c) Endurance limit d) Yield point

303. This type of load is the one that is applied slowly and never removed. How do you call this load?
a) Static load b) Fluctuating load c) Random load d) Fluctuating load

304. At the highest point of the stress-strain curve during the test, what highest stress on a test bar of the material is measured?
a) Apparent stress b) Ultimate stress c) Elastic stress d) Yield stress

305. This is a stress when a given element of a load-carrying member is subjected to a certain level of tensile stress followed by the same level of compressive stress; the stress cycle is repeated many thousands of times. How do you call this type of stress?
a) Repeated and Reversed Stress b) Static stress c) Minimum stress d) Maximum stress

306. These steels contain 30 to 50 points of carbon (0.30%-0.50%). Most machine elements having moderate to high strength requirements with fairly good ductility and moderate hardness requirements come from this group.
a) High-carbon steels **b) Medium-carbon steels** c) Low-carbon steels d) Alloy steels

307. It is the process of increasing the hardness and strength of ductile material as it is plastically performed. How do you call this process?
a) Strain hardening b) Surface hardening c) Cold hardening d) Hot hardening

308. Which of the following the average density of a leather belts?
a) 0.035 lb/in^3 b) 0.253 lb/in^3 c) 0.046 lb/in^3 d) 0.074 lb/in^3

309. As a flat belt drive designer, what must be the belt speed to make your design most economical?
a) 4000 to 4500 fpm b) 2000 to 3000 fpm c) 3000 to 4000 fpm d) 4000 to 5000 fpm

310. As suggested by Taylor, what is the recommended initial tension of belt,?
a) 75 lb/in of width **b) 71 lb/in of width** c) 73 lb/in of width d) 80 lb/in of width

311. Not adaptable to welding due to low tensile strength and poor ductility etc.
a) copper parts **b) aluminum parts** c) cast iron materials d) bronze parts

312. Bearing surface that completely surrounds the journal is also called:
a) offset bearing b) centrally loaded bearing **c) full bearing** d) babbit bearing

313. The purpose of lubrication is as mentioned except:
a) to lighten the load **b) prevent adhesion** c) prevent corrosion/oxidation d) cool the moving elements

314. Tools usually used in wood pattern making in foundry shop.
a) saws and chisel b) knives and drills c) band saw d) drill machine

315. This group of materials characterizes the high level of corrosion resistance offered by alloys in this group. To be classified on this group of material, the alloy must have a chromium con tent of at least 10%, and most have 12% to 18% chromium.
a) Stainless steels b) Structural steels c) Tool steels d) Mild steels

316. The ability of the material to absorb energy up to fracture.
a) Toughness b) Rigidity c) Resilience d) Stiffness

317. These group of stainless steels fall into the AISI 200 and 300 series. They are general-purpose grades with moderate strength. Most are not heat-treatable, and their final properties are determined by the amount of working, with the resulting temper referred to as 1/4 hard, ½ hard, 3/4 hard, and full hard. These alloys are nonmagnetic and are typically used in food processing equipment.
a) Austenitic stainless steels b) Ferritic stainless steels c) Martensitic stainless steels d) None of these

318. These stainless steels belong to the AISI 400 series, designated as 405, 409, 430, 446, and so on. They are magnetic and perform well at elevated temperatures, from 1300°F to 1900°F (700°C-1040°C), depending on the alloy. They are not heat-treatable, but they can be cold-worked to improve properties. Typical applications include heat exchanger tubing, petroleum refining equipment, automotive trim, furnace parts, and chemical equipment.
a) Austenitic stainless steels **b) Ferritic stainless steels** c) Martensitic stainless steels d) None of these

319. These stainless steels are also members of the AISI 400 series, including 403, 410, 414, 416, 420, 431, and 440 types. They are magnetic, can be heat-treated, and have higher strength than the 200 and 300 series, while retaining good toughness. Typical uses include turbine engine parts, cutlery, .scissors, pump parts, valve parts, surgical instruments, aircraft fittings, and marine hardware.
a) Austenitic stainless steels b) Ferritic stainless steels **c) Martensitic stainless steels** d) None of these

320. Most of these materials are designated by ASTM numbers established by the American Society for Tesfing and Materials. One common grade is ASTM A36, which has a minimum yield point of 36 000 psi (248 MPa) and is very ductile. It is basically a low-carbon, hot-rolled steel available in sheet, plate, bar, and structural shapes such as some wide-flange beams, American Standard beams, channels, and angles.
a) Structural steels b) Tool steels c) Cast steels d) Stainless steels

321. Compounds of metallic elements, most frequently oxides, nitrides, and carbides.
a) Plastic b) Polymers **c) Ceramics** d) Alloy

322. This material refers to a group of steels typically used for cutting tools, punches, dies, shearing blades, chisels, and similar uses. The numerous varieties of tool steel materials have been classified into seven general types. Whereas most uses of these steels are related to the field of manufacturing engineering, they are also pertinent to machine design where the ability to maintain a keen edge under abrasive conditions is required. Also, some of these steels have rather high shock resistance which may be desirable in machine components such as parts for mechanical clutches, pawls, blades, guides for moving materials, and clamps.
a) Structural steels **b) Tool steels** c) Cast steels d) Stainless steels

323. A material having different properties in all directions at point in solid.
a) Isotropic material **b) Anisotropic material** c) Orthotropic material d) Ceramic material

324. Parts subjected to repeated applications of loads or to stress conditions that vary with time over several thousands or millions of cycles fail because of the phenomenon *of fatigue.* Materials are tested under controlled cyclic loading to determine their ability to resist such repeated loads. The resulting data are reported as which of the following?
a) Endurance strength b) Ultimate strength c) Yield strength d) Elastic strength

325. Which of the following is the other term for endurance strength?
a) Fatigue strength b) Ultimate strength c) Yield strength d) Elastic strength

326. A material having different properties in three mutually perpendicular directions at point in solid and having three mutually perpendicular planes of material symmetry.
a) Orthotropic material b) Isotropic material c) Anisotropic material d) Thermoplastic material

327. The onset of plastic deformation is called:
a) Necking b**. yielding** c. creeping d. buckling