Answer Key

MACHINE DESIGN

Refresher 02

1

$$\epsilon = \frac{\delta}{L}$$

$$0.0008\ \frac{in}{in} = \frac{\delta}{(35ft)\left(\frac{12in}{1ft}\right)}$$

$$\boxed{\delta = 0.335\ in}$$

2

Length of Belt

$$L = \frac{\pi}{2}(D+d) + 2c + \frac{(D-d)^2}{4c}$$

$$= \frac{\pi}{2}(12'' + 7.5'') + 2(45'') + \frac{(12'' - 7.5'')^2}{4(45'')}$$

$$L = 120.7430 \text{ in}$$

$$\boxed{L = 121 \text{ in}}$$

3

SPEED OF The belt

$$v = \frac{\pi d N}{60} = \frac{\pi (7.5\ in)\left(\frac{1\ ft}{12\ in}\right)(1700\ rpm)}{60}$$

$$\boxed{v = 55.6324\ ft/sec}$$

4

Shear Stress concentration factor

$$k_s = \frac{2c+1}{2c} \quad ; \quad c = \frac{D_m}{d} = \frac{D_o - d}{d}$$

$$= \frac{\left(9/16'' - 0.090''\right)}{0.090''}$$

$$c = 5.25$$

substi;

$$k_s = \frac{2(5.25)+1}{2(5.25)}$$

$$\boxed{k_s = 1.0952}$$

5

Bergstrasser Factor

$$K_B = \frac{4c+2}{4c-3} = \frac{4(5.25)+2}{4(5.25)-3}$$

$$\boxed{K_B = 1.2778}$$

6

Load of the beam

Shrink fit

8

Cape chisel

9

Pitch line Velocity

$$v = \frac{\pi D_1 N}{60}$$; transverse Circular Pitch

$$P_n = P \cos \phi$$

$$= 12 \frac{\text{teeth}}{\text{in}} \cos 30°$$

$$P_n = 10.3923 \frac{\text{teeth}}{\text{in}}$$

and;

$$P = \frac{T_1}{D_1}$$

$$10.3923 = \frac{18}{D_1}$$

$$D_1 = 1.7320 \text{ in}$$

hence;

$$v = \frac{\pi (1.7320 \text{ in})(1 \text{ ft}/12 \text{ in})(1500 \text{ rpm})}{60}$$

$$\boxed{v = 11.3359 \text{ ft/sec}}$$

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transmitted load

$$Hp = \frac{Fv}{33000}$$

$$1.8\ hp = \frac{F\left(11.3359\ ft/sec\right)\left(\frac{60 sec}{1 min}\right)}{33000}$$

$$\boxed{F = 87.3332\ lbs}$$

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$$S_s = \frac{PD}{2t} = \frac{(160\ lb/in^2)(25\ in)}{2(0.125\ in)}$$

$$\boxed{S_s = 16000\ psi}$$

12

$$\delta = \frac{8Fc^3n}{dG}$$

$$0.5\,in = \frac{8(60\,lbs)(6)^3(15)}{d(12\times10^6\ lb/in^2)}$$

$$\boxed{d = 0.2592\ in}$$

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Mean diameter

$$C = \frac{D_m}{d}$$

$$6 = \frac{D_m}{0.2592\ in}$$

$$\boxed{D_m = 1.5552\ in}$$

Epicycloids

15

Contact ratio

16

20 deg

17

$$V_{rim} = bt\pi D \quad ; \quad \rho_{rim} = \frac{m}{V_{rim}}$$

$$\frac{m}{\rho_{rim}} = bt\pi D$$

Solving for the mass, m

$$\Delta E = \frac{F}{g_o} C_f (v_a{}^2)$$

$$v = \frac{\pi D N}{60} = \frac{\pi (6\,ft)(280\,rpm)}{60}$$

$$v = 87.9646\ ft/sec$$

Subst;

$$2500\,ft\text{-}lb = \frac{F}{32.2\,ft/sec^2}(0.04)(87.9646\,ft/sec)^2$$

$$F = m = 260.0878\ lb$$

Hence;

$$\frac{260.0878\,lbs}{0.260\,lb/in^3} = (12\,in)\,t\,\pi(6\,ft)\left(\frac{12\,in}{1\,ft}\right)$$

$$\boxed{t = 0.3685\ in}$$

18

RADIUS OF GYRATION

$$R = \sqrt{8.68 \times 10^{-4} (D_o^2 + D_i^2)} \quad ; \text{ft}$$

$$= \sqrt{8.68 \times 10^{-4} \left[(24\text{ in})^2 + (18\text{in})^2\right]}$$

$$\boxed{R = 0.8839 \text{ ft}}$$

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Exponential LEAP ONLINE REVIEW

Torque required

$$T = \frac{FR^2}{g_o}\left[\frac{2\pi(n_2 - n_1)}{60t}\right]$$

$$= \frac{(220\ lbs)(0.8839\ ft)^2}{32.2\ ft/sec^2}\left[\frac{2\pi(220 - 160)\ rpm}{60(15\ sec)}\right]$$

$$T = (2.2359\ ft\text{-}lb)\left(\frac{12\ in}{1\ ft}\right)$$

$$\boxed{T = 26.8314\ lb\text{-}in}$$

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Melting

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Babbit

22

$$P = \frac{2\pi T N}{60} \quad ; \quad S_s = \frac{16T}{\pi d^3}$$

$$5800\ \frac{lb}{in^2} = \frac{16\ T}{\pi (0.25\ in)^3}$$

$$T = 17.7942\ lb\text{-}in$$

Subst:

$$P = \frac{2\pi (17.7942\ lb\text{-}in)\left(\frac{1\ ft}{12\ in}\right)(2200\ rpm)}{60}$$

$$P = \left(341.62377\ \frac{lb\text{-}ft}{sec}\right)\left(\frac{1\ hp}{550\ \frac{lb\text{-}ft}{s}}\right)$$

$$\boxed{P = 0.6211\ hp}$$

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ω_{c_1} (SHAFT) = 110 rad/sec

ω_{c_2} (pulley) = 130 rad/sec

ω_{c_3} (gear) = 125 rad/sec

CRITICAL speed of the system

from: Dunkerley's Equation

$$\frac{1}{\omega_{c_s}^2} = \frac{1}{\omega_{c_1}^2} + \frac{1}{\omega_{c_2}^2} + \frac{1}{\omega_{c_3}^2} + \dots + \frac{1}{\omega_{cn}^2}$$

$$\frac{1}{\omega_{c_s}^2} = \frac{1}{\left(110\ \frac{rad}{sec}\right)^2} + \frac{1}{\left(130\ \frac{rad}{sec}\right)^2} + \frac{1}{\left(125\ \frac{rad}{sec}\right)^2}$$

$$\boxed{\omega_{c_2} = 69.7044\ \frac{rad}{sec}}$$

Composition of forces

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exponential LEAP
ONLINE REVIEW

$$\Delta L = \alpha L \Delta T$$
$$= (6.5 \times 10^{-6})(12\,in)(145 - 80)\,deg\,F$$
$$\Delta L = 5.07 \times 10^{-3}\ in$$

then;

$$S_s = E\,\frac{\delta}{L} = \left(30 \times 10^{6}\ \frac{lb}{in^2}\right)\left(\frac{5.07 \times 10^{-3}\ in}{12\ in}\right)$$

$$\boxed{S_s = 12675\ \frac{lb}{in^2}}$$

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$$\delta = \frac{PL}{AE}$$

$$8\,mm = \frac{P(5000\,mm)}{\frac{\pi(7\,mm)^2}{4}\left(180 \times 10^3 \frac{N}{mm^2}\right)}$$

$$\boxed{P = 11083.5368\ N}$$

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Metal

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Exponential LEAP
ONLINE REVIEW

$$\Delta E = \frac{F}{4g_o}\left(V_1^2 - V_2^2\right)$$ for solid disc flywheels

Peripheral speed

$$V_2 = V_1 - 0.12V_1 = V_1(1-0.12)$$

$$= 65\ ft/sec\,(1-0.12)$$

$$V_2 = 57.2\ ft/sec$$

$$V_1 = 65\ ft/sec$$

Subst;

$$\Delta E = \frac{320\ lbs}{4\left(32.2\ ft/sec^2\right)}\left(65^2 - 57.2^2\right) ft^2/sec^2$$

$$\boxed{\Delta E = 2368.0994\ ft\text{-}lb}$$

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Force Required to punch a hole

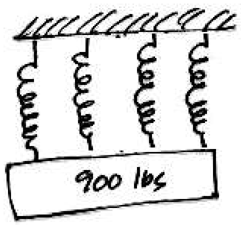
$$S_{su} = \frac{F}{\pi D t}$$

$$60000\,\frac{lb}{in^2} = \frac{F}{\pi(1.5\,in)(3/4\,in)}$$

$$\boxed{F = 212\,057.5041\ lbs}$$

30

5000/6000



$k_1 = k_2 = k_3 = 45\ lb/in$

Deflection

$$k = \frac{P}{\delta}$$

$$45\ lb/in = \frac{900\ lbs/4}{\delta}$$

$$\boxed{\delta = 5\ in}$$

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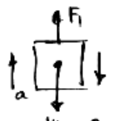
Exponential LEAP ONLINE REVIEW

FBD of the load

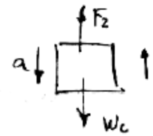


$[\Sigma F_y = 0]$

$$F_1 - W_T = m_T\left(\frac{a}{g_c}\right)$$

$$F_1 - W_T - m_T\left(\frac{a}{g_c}\right) = 0 \longrightarrow (1)$$

FBD of the counterweight



$[\Sigma F_y = 0]$

$$F_2 - W_c = -m_c\left(\frac{a}{g_c}\right)$$

$$F_2 - W_c + m_c\left(\frac{a}{g_c}\right) = 0 \longrightarrow (2)$$

from eq (2)

$$W_c = m_c\left(\frac{g_o}{g_c}\right)$$

$$m_c = W_c\left(\frac{g_c}{g_o}\right)$$

$$F_2 - W_c + W_c\left(\frac{a}{g_o}\right) = 0$$

$$F_2 - 3350\text{ lb} + 3350\text{ lb}\left(\frac{4\text{ ft/sec}^2}{32.2\text{ ft/sec}^2}\right)$$

$$F_2 = 2933.8509\text{ lbs}$$

from: $\frac{F_1}{F_2} = e^{f\theta}$

$$F_1 = F_2 e^{f\theta} = F_2 e^{(0.3)(535°)(\pi/180°)}$$

$$F_1 = 2.5440 F_2 \longrightarrow (3)$$

From eq (3)

$$F_1 = 2.5440(2933.8509\text{ lbs})$$

$$F_1 = 7463.7168\text{ lbs}$$

hence; from 1

$$F_1 - W_T - m_T\left(\frac{g}{g_c}\right) = 0$$

$$m_T = W_T\left(\frac{g_c}{g_o}\right)$$

$$F_1 - W_T - W_T\left(\frac{a}{g_o}\right) = 0$$

$$7463.7168\text{ lbs} - W_T\left(1 + \frac{4\text{ ft/sec}^2}{32.2\text{ ft/sec}^2}\right) = 0$$

$$\boxed{W_T = 6638.9967\text{ lbs}}$$

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Machine

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$v = \pi D N$

$$\left(1200\ \text{ft/min}\right)\left(\frac{12\ \text{in}}{1\ \text{ft}}\right) = \pi D \left(200\ \text{ft/min}\right)$$

$$\boxed{D = 22.9183\ \text{in}}$$

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exponential LEAP
ONLINE REVIEW

Thickness Required

$$S_s = \frac{PD}{2t} \quad ; \quad P = \gamma h$$

$$= \left(530\ \frac{kg}{m^3}\right)\left(\frac{9.81\ m/s^2}{1\ \frac{kg-m}{N-s^2}}\right)(7m)$$

$$P = 36,395.1\ \frac{N}{M^2}$$

subst;

$$30 \times 10^6\ \frac{N}{m^2} = \frac{(36,395.1\ N/m^2)(3.4m)}{2t}$$

$$t = 2.0624 \times 10^{-3}\ m$$

$$\boxed{t = 2.0624\ mm}$$

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$$S_s = \frac{PD}{4t\eta}$$

$$65000\ \frac{lb}{in^2} = \frac{P(14\,in)}{4(1/4\,in)(0.80)}$$

$$\boxed{P = 3714.2857\ psi}$$

Exponential LEAP ONLINE REVIEW

Tempering

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Reduce concentration factor

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$$\alpha = \frac{\omega_2 - \omega_1}{t}$$

$$= \frac{(860 - 320)\,\frac{\text{rev}}{\text{min}}\left(\frac{1\ \text{min}}{60\ \text{sec}}\right)\left(\frac{360^\circ}{1\ \text{rev}}\right)\left(\frac{\pi\ \text{rad}}{180^\circ}\right)}{38\ \text{sec}}$$

$$\boxed{\alpha = 1.4881\ \frac{\text{rad}}{\text{sec}^2}}$$

40

Copper

Short shaft

$$P = \frac{D^3 N}{38} = \frac{(2.8\text{ in})^3 (300\text{ rpm})}{38}$$

$$\boxed{P = 173.3053\text{ hp}}$$

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Polar section modulus

$$z = 0.05\,s^3$$

$$z = 0.05(4\,in)^3$$

$$\boxed{z = 3.2\ in^3}$$

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Flange coupling

$$P = \frac{2\pi T N}{60}$$

$$27.5\ kW = \frac{2\pi T (450\ rpm)}{60}$$

$$T = 0.5836\ kN\text{-}m$$

and;

$$S_s = \frac{2T}{D\left[\frac{\pi}{4} h^2\right] N_b}$$

$$15 \times 10^3\ \frac{kN}{m^2} = \frac{2(0.5836\ kN\text{-}m)}{0.120\ m\left[\frac{\pi}{4} h^2\right] 4}$$

$$h = 0.01436\ m$$

$$\boxed{h = 14.36\ mm}$$

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Exponential LEAP ONLINE REVIEW

$$\frac{\theta}{L} = \frac{T}{JG} \; ; \qquad P = \frac{2\pi T N}{60}$$

$$(50\,hp)\left(\frac{550\ \frac{ft\text{-}lb}{sec}}{1\,hp}\right) = \frac{2\pi T\,(1300\ rpm)}{60}$$

$$T = 202.00\ lb\text{-}ft$$

$$J = \frac{\pi D^4}{32} = \frac{\pi\left[(1.50\,in)\left(\frac{1\,ft}{12\,in}\right)\right]^4}{32}$$

$$J = 2.3968 \times 10^{-5}\ ft^4$$

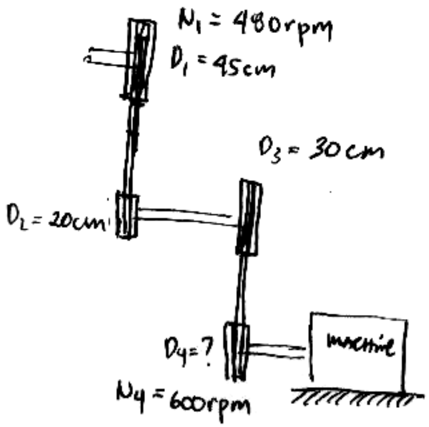
Subst;

$$\frac{\theta}{L} = \frac{(202.00\ lb\text{-}ft)}{(2.3968 \times 10^{-5}\ ft^4)\left(12.3 \times 10^6\ \frac{lb}{in^2}\right)\left(\frac{144\ in^2}{1\ ft^2}\right)}$$

$$\frac{\theta}{L} = \left(4.758 \times 10^{-3}\ \frac{rad}{ft}\right)\left(\frac{180^\circ}{\pi\ rad}\right)$$

$$\boxed{\frac{\theta}{L} = 0.2726\ \frac{deg}{ft}}$$

45



$$D_1 N_1 = D_2 N_2$$

$$(45 cm)(480 rpm) = (20 cm) N_2$$

$$N_2 = 1080 rpm = N_3$$

Then;

$$D_3 N_3 = D_4 N_4$$

$$(30 cm)(1080 rpm) = D_4 (600 rpm)$$

$$\boxed{D_4 = 54 cm}$$

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$$P = \frac{D^3 N}{38} \quad ; \quad D = (40\,mm)\left(\frac{1\,in}{25.4\,mm}\right) = 1.5748\,in$$

$$N = \left(20\,\frac{rad}{sec}\right)\left(\frac{60\,sec.}{1\,min}\right)\left(\frac{180^\circ}{\pi\,rad}\right)\left(\frac{1\,rev}{360^\circ}\right)$$

$$N = 190.9859\ rpm$$

subst;

$$P = \frac{(1.5748\,in)^3(190.9859\,rpm)}{38}$$

$$\boxed{P = 19.6289\ hp}$$

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Class C

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Ball bearing

$$S_s = \frac{16T}{\pi d^3} = \frac{16\,(0.5\text{ kN-m})\left(\frac{1000\text{ N}}{1\text{ kN}}\right)\left(\frac{1000\text{ mm}}{1\text{ m}}\right)}{\pi\,(60\text{ mm})^3}$$

$$\boxed{S_s = 11.7893\text{ MPa}}$$

50

127

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Equilibrium is maintained

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Worm gear

53

UNC

54

Sprocket

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$$S_s = \frac{16T}{\pi d^3} \; ; \qquad P = \frac{2\pi T N}{60}$$

$$(80\ hp)\left(\frac{550\ \frac{lb-ft}{sec}}{1\ hp}\right) = \frac{2\pi T\,(1900\ rpm)}{60}$$

$$T = 221.1416\ lb-ft$$

subst;

$$6500\ \frac{lb}{in^2} = \frac{16\,(221.1416\ lb-ft)\left(\frac{12\ in}{1\ ft}\right)}{\pi d^3}$$

$$d = 1.2763\ in$$

$$\boxed{d = 1 - 5/18''}$$

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Exponential LEAP ONLINE REVIEW

Based on shear

$$S_s = \frac{2T}{dbL}$$

$$60\ \frac{N}{mm^2} = \frac{2(1300\ N\text{-}m)\left(\frac{1000\ mm}{1\ m}\right)}{(65\ mm)(13\ mm)L}$$

$$L = 51.2820\ mm$$

Based on tension

$$S_c = \frac{F_c}{A_c}\ ;\ T = F_c\left(\frac{d}{2}\right)\ ;\ A = \left(\frac{t}{2}\right)L$$

$$(1300\ N\text{-}m)\left(\frac{1000\ mm}{1\ m}\right) = F_c\left(\frac{65\ mm}{2}\right)$$

$$F_c = 40000\ N$$

Substi

$$95\ \frac{N}{mm^2} = \frac{40000\ N}{\left(\frac{15\ mm}{2}\right)(L)}$$

$$L = 56.1404\ mm$$

$\boxed{\text{choose: } 56.1404\ mm}$

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exponential LEAP
ONLINE REVIEW

$$\theta = \frac{TL}{JG} \quad ; \quad S_s = \frac{16T}{\pi d^3}$$

$$T = \frac{\theta JG}{L} \quad ; \quad T = \frac{\pi S_s d^3}{16}$$

equating

$$\frac{\theta JG}{L} = \frac{\pi S_s d^3}{16} \quad ; \quad J = \frac{\pi d^4}{32}$$

$$\frac{\cancel{\pi} d^4 \theta G}{32 L} = \frac{\cancel{\pi} S_s d^3}{16}$$

$$d = \frac{2 S_s L}{\theta G}$$

Hence;

$$d = \frac{2\left(75\ N/mm^2\right)\left(700mm\right)}{\left(0.8deg\right)\left(\frac{\pi\ rad}{180^\circ}\right)\left(75 \times 10^3\ \frac{N}{mm^2}\right)}$$

$$\boxed{d = 100.2676\ mm}$$

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$$\theta = \frac{TL}{JG} \quad ; \quad P = \frac{2\pi TN}{60}$$

$$60\ kW = \frac{2\pi T(480\ rpm)}{60}$$

$$T = 1.1937\ kN\text{-}m$$

$$S_s = \frac{16T}{\pi d^3}$$

$$45\times10^3\ \frac{kN}{m^2} = \frac{16(1.1937\ kN\text{-}m)}{\pi d^3}$$

$$d = 0.05131\ m$$

and from;

$$J = \frac{\pi d^4}{32} = \frac{\pi(0.05131\ m)^4}{32} = 6.8053\times10^{-7}\ m^4$$

Hence;

$$\theta = \frac{(1.1937\ kN\text{-}m)(12\ m)}{(6.8053\times10^{-7}\ m^4)(80\times10^6\ \frac{kN}{m^2})}$$

$$\theta = (0.2631\ rad)\left(\frac{180^\circ}{\pi\ rad}\right)$$

$$\boxed{\theta = 15.0749\ \text{degrees.}}$$

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$$S_s = \frac{16T}{\pi d^3} \quad ; \quad P = \frac{2\pi T N}{60}$$

$$25\ kW = \frac{2\pi T\,(720\ rpm)}{60}$$

$$T = 0.3316\ kN\text{-}m$$

Subst;

$$S_s = \frac{16(0.3316\ kN\text{-}m)}{\pi\,(0.030\ m)^3}$$

$$\boxed{S_s = 62549.0715\ kPa}$$

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Exponential LEAP ONLINE REVIEW

$$S_s = \frac{16T}{\pi d^3}$$; $WP = Q\gamma TDH$

$$= \left(2800\frac{L}{min}\right)\left(\frac{1 m^3}{1000 L}\right)\left(\frac{1 min}{60 s}\right)\left(9.81\frac{kN}{m^3}\right)(14 m)$$

$$WP = 6.4092 \text{ kW}$$

and;

$$\eta_p = \frac{WP}{WP'}$$

$$0.70 = \frac{6.4092 \text{ kW}}{WP'}$$

$$WP' = 9.1560 \text{ kW}$$

from;

$$P = \frac{2\pi TN}{60}$$

$$9.1560 \text{ kW} = \frac{2\pi T(620 \text{ rpm})}{60}$$

$$T = 0.1410 \text{ kN-m}$$

Hence;

$$S_s = \frac{16(0.1410 \text{ kN-m})}{\pi(0.038 m)^3}$$

$$S_s = 13086.9497 \frac{kN}{m^2}$$

$$\boxed{S_s = 13.08 \text{ MPa}}$$

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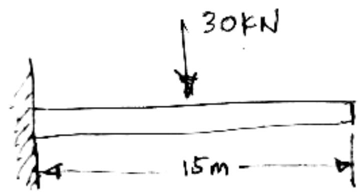

$$\theta = \frac{FL^2}{8EI} = \frac{(30\,kN)(15\,m)^2}{8(10000\,kN\text{-}m^2)}$$

$$\boxed{\theta = 0.0844\ rad}$$

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Silver-gray

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Lateral deformation to the longitudinal deformation

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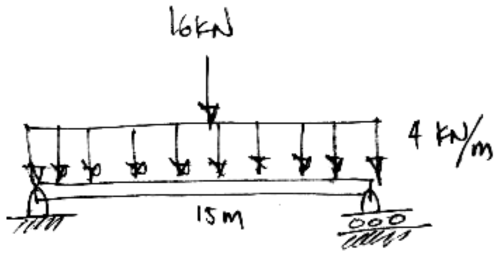
Exponential LEAP ONLINE REVIEW



Uniform load

$$y_1 = \frac{5WL^4}{384EI} = \frac{5(4\,kN/m)(15m)^4}{384(12{,}000\,kN\text{-}m)}$$

$$y_1 = 0.2197\ m$$

concentrated load

$$y_2 = \frac{FL^3}{48EI} = \frac{(16\,kN)(15m)^3}{48(12000\,kN\text{-}m^2)}$$

$$y_2 = 0.09375\ m$$

Hence;

$$y_T = y_1 + y_2 = (0.2197 + 0.09375)m$$

$$y_T = 0.3135\ m$$

$$\boxed{y_T = 313.45\ mm}$$

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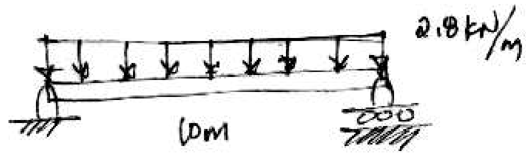

$$y = \frac{5wL^4}{384EI} = \frac{5(2.8\ kN/m)(10m)^4}{384(7200\ kN\text{-}m^2)}$$

$$y = 0.04521\ m$$

$$\boxed{y = 45.21\ mm}$$

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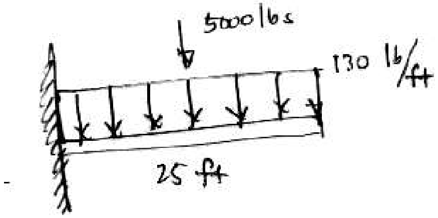
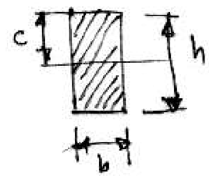
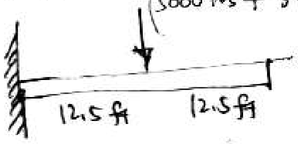




Simplifying $(5000 \text{ lbs} + 3250 \text{ lbs}) = 8250 \text{ lbs}$



$$S_f = \frac{Mc}{I} \; ; \; I = \frac{bh^3}{12} \quad (\text{for rectangular section})$$

$$S_f = \frac{6M}{bh^2} \; ; \text{psi}$$

$$M = (8250 \text{ lbs})(12.5 \text{ ft})\left(\frac{12 \text{ in}}{1 \text{ ft}}\right) = 1237500 \text{ lb-in}$$

Hence;

$$S_f = \frac{6(1237500 \text{ lb-in})}{(9 \text{ in})(12 \text{ in})^2}$$

$$\boxed{S_f = 5729.1667 \text{ lb/in}^2}$$

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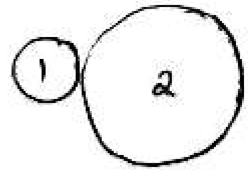

$T_g = 56$ teeth

$$\frac{n_p}{n_g} = \frac{D_g}{D_p} = \frac{T_g}{T_p}$$

$$\frac{4}{1} = \frac{56 \text{ teeth}}{N_p}$$

$$\boxed{T_p = 14 \text{ teeth}}$$

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exponential LEAP
ONLINE REVIEW

$$T = f\, F_a \left[\frac{D^3 - d^3}{3(D^2 - d^2)}\right] N_c$$

$$= (0.38)(520\ \text{lbs})\left[\frac{(9\,\text{in})^3 - (4.5\,\text{in})^3}{3(9^2 - 4.5^2)}\right](1)$$

$$\boxed{T = 691.6\ \text{lb-in}}$$

70

Cone clutch

$$T = \frac{F_a f r_f}{\sin\theta} = \frac{(650N)(0.40)(0.230/2\ m)}{\sin 12^\circ}$$

$$\boxed{T = 143.8111\ N\text{-}m}$$

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Dry

72

92xx

73

V-belt

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cone clutch using uniform wear method

$$T = \frac{F_a f r_f}{\sin\theta} \quad ; \quad P = \frac{2\pi T N}{60}$$

$$10\text{ kW} = \frac{2\pi T(550\text{ rpm})}{60}$$

$$T = 0.1736\text{ kN-m}$$

subst;

$$0.1736\text{ kN-m} = \frac{F_a(0.39)\left(\frac{0.30\text{ m}}{2}\right)}{\sin 11^\circ}$$

$$F_a = 0.5662\text{ kN}$$

$$\boxed{F_a = 566.2\text{ N}}$$

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Micrometer

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xponential LEAP
ONLINE REVIEW

$$S_t = \frac{F_1}{bt}$$

$$60\ N/mm^2 = \frac{8000\ N}{b(5\ mm)}$$

$$\boxed{b = 26.67\ mm}$$

$$F_1 - F_2 = 5\,kN \; ; \quad \frac{F_1}{F_2} = 4$$

$$F_1 = 4F_2$$

Subst;

$$4F_2 - F_2 = 5\,kN$$

$$F_2 = 1.6667\,kN$$

$$\boxed{F_1 = 6.6668\,kN}$$

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$$F_1 = 3F_2$$

$$\frac{F_1}{F_2} = 3$$

from; $\frac{F_1}{F_2} = e^{f\theta}$

$$3 = e^{0.30\,\theta}$$

$$\theta = (3.6620 \text{ rad})\left(\frac{180°}{\pi \text{ rad}}\right)$$

$$\boxed{\theta = 209.8171 \text{ deg}}$$

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$$P = 2\pi T N \; ; \quad T = (F_1 - F_2) r$$

$$= (5 \text{ kN})\left(\frac{1.2}{2} \text{ m}\right)$$

$$T = 3 \text{ kN-m}$$

subst;

$$P = \frac{2\pi (3 \text{ kN-m})(320 \text{ rpm})}{60}$$

$$\boxed{P = 100.5309 \text{ kW}}$$

80

$$D = \frac{P}{\sin\left(\frac{180^\circ}{T}\right)}$$

$$28.654 \text{ in} = \frac{P}{\sin\left(\frac{180^\circ}{90}\right)}$$

$$\boxed{P = 1.00 \text{ in}}$$

81

$$D = \frac{P}{\sin\left(\frac{180^\circ}{T}\right)}$$

$$9.56 \text{ in} = \frac{\frac{1}{2} \text{ in}}{\sin\left(\frac{180^\circ}{T}\right)}$$

$$\sin\left(\frac{180^\circ}{T}\right) = 0.05230$$

$$\frac{180^\circ}{T} = 2.998^\circ$$

$$\boxed{T = 60 \text{ teeth}}$$

82

$$V = \frac{\pi D N}{60} = \frac{P T N}{60} = \frac{(3/4\ in)\left(\frac{1\ ft}{12\ in}\right)(24)(620\ rpm)}{60}$$

$$V = \left(15.5\ ft/sec\right)\left(\frac{60\ sec}{1\ min}\right)$$

$$\boxed{V = 930\ fpm}$$

83

$$D = \frac{P}{\sin\left(\frac{180^\circ}{T}\right)} = \frac{0.5\text{ in}}{\sin\left(\frac{180^\circ}{20}\right)}$$

$$\boxed{D = 3.1962\text{ in}}$$

84

Given: $600 \frac{kN}{m^2}$ per unit load

$$S_b = \frac{F}{bL} \quad ; \quad \frac{C_d}{D} = 0.0013$$

$$\frac{0.130\,mm}{D} = 0.0013$$

$$D = 100\,mm$$

Subst;

$$600 \frac{kN}{m^2} = \frac{30\,kN}{(0.1\,m)\,L}$$

$$L = 0.5\,m$$

$$\boxed{L = 500\,mm}$$

$$T_b = F f_b \frac{D}{2} \quad ; \quad F = \frac{60\,kN}{2} = 30\,kN \text{ load per bearing}$$

subst;

$$T_b = (30\,kN)(0.11)\left(\frac{0.22}{2}\,m\right)$$

$$T_b = 0.363\ kN\text{-}m$$

Hence;

$$P = \frac{2\pi T_b N}{60} = \frac{2\pi(0.363\ kN\text{-}m)(480\,rpm)}{60}$$

$$\boxed{P = 18.2464\ kW}$$

86

$$T_b = F f_b \frac{D}{2} = \left(\frac{4800\,kg}{2}\right)\left(\frac{9.81\ m/s^2}{1\ \frac{kg\text{-}m}{N\text{-}s^2}}\right)(0.20)\left(\frac{0.160\,m}{2}\right)$$

$$\boxed{T_b = 376.704\ N\text{-}m}$$

87

Bearing stress

$$S_b = \frac{F}{bL} = \frac{\left(\frac{4500\ kg}{2}\right)\left(\frac{9.81\ m/s^2}{1000\ \frac{kg-m}{kN-s^2}}\right)}{(0.155\ m)(0.290\ m)}$$

$$\boxed{S_b = 493.5456\ \frac{kN}{m^2}}$$

Left

89

Foundry

90

Newton's Law

Packings

92

Exponential LEAP ONLINE REVIEW

$$C = \frac{D_1 + D_2}{2} \; ; \quad P_d = \frac{T}{D}$$

$$D_1 = \frac{T_1}{P_d} = \frac{14 \text{ teeth}}{8} = 1.75 \text{ in}$$

$$D_2 = \frac{T_2}{P_d} = \frac{38 \text{ teeth}}{8} = 4.75 \text{ in}$$

Subst;

$$C = \frac{(1.75 + 4.75)\text{ in}}{2}$$

$$\boxed{C = 3.25 \text{ in}}$$

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$$P = \frac{D^3 N}{80}$$

$$300\ hp = \frac{\left[(55\ mm)\left(\frac{1\ in}{25.4\ mm}\right)\right]^3 N}{80}$$

$$\boxed{N = 2363.8739\ rpm}$$

94

Gear Ratio $= \frac{T_2}{T_1} = 4$

$C = 12$ in

$T_2 = 64$

$P_c = \frac{\pi D}{T}$; $\frac{T_2}{T_1} = \frac{N_1}{N_2}$; $\frac{N_1}{N_2} = \frac{D_2}{D_1}$

$$\frac{T_2}{T_1} = \frac{D_2}{D_1}$$

$$4 = \frac{D_2}{D_1}$$

$$D_2 = 4D_1$$

$$C = \frac{D_1 + D_2}{2}$$

$$12 \text{ in} = \frac{D_1 + 4D_1}{2}$$

$$D_1 = 4.8 \text{ in}$$

$$D_2 = 19.2 \text{ in}$$

Hence;

$$P_c = \frac{\pi D_2}{T_2} = \pi\left(\frac{19.2 \text{ in}}{64 \text{ teeth}}\right)$$

$$\boxed{P_c = 0.9425 \text{ in/teeth}}$$

95

$$W = S_t\left(0.55d^2 - 0.25d\right)$$

$$= 14000\ \frac{lb}{in^2}\left[(0.55)(1.5\,in)^2 - 0.25(1.5)\right]$$

$$\boxed{W = 4278.75\ lbs}$$

96

for 14.5° tooth thickness ; $t = \frac{1.5708}{P_d}$

$$t = \frac{1.5708}{8 \text{ teeth/in}}$$

$$t = (0.19635 \text{ in})\left(\frac{25.4 \text{ mm}}{1 \text{ in}}\right)$$

$$\boxed{t = 4.9873 \text{ mm}}$$

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Hypoid

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Allowance

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Resilience

100

To sign plans, specifications, design etc.