# Answer Key

Helical Gear, Worm Gear and Bevel Gear

$$F_a = F_t \cos \psi$$

$$75 \text{ lbs} = 220 \text{ lbs} \cos \psi$$

$$\psi = 70.0677°$$

$$P_{dn} = \frac{P_d}{\cos\psi} \quad ; \quad P_d = \frac{T}{D} = \frac{22\ \text{teeth}}{6\ \text{in}} = 3.6667$$

$$P_{dn} = \frac{3.6667}{\cos 20^\circ}$$

$$P_{dn} = 3.9020$$

$$P = 2\pi TN$$

$$(80\,hp)\left(\frac{550\ \frac{ft\text{-}lb}{sec}}{1\,hp}\right) = \frac{2\pi T(460\ rpm)}{60}$$

$$T = 913.41098\ ft\text{-}lb$$

and;

$$T = F_t r$$

$$913.41098\ ft\text{-}lb = F_t\left(\frac{9\,in}{2}\right)\left(\frac{1\,ft}{12\,in}\right)$$

$$F_t = 2435.7626\ lbs$$

$$\tan \phi_n = \tan \phi \cos \psi$$

$$\tan \phi_n = \tan 20^\circ \cos 22^\circ$$

$$\phi_n = \tan^{-1}(0.3375)$$

$$\boxed{\phi_n = 18.6479^\circ}$$

$$P_{cn} = P_c \cos\psi$$

$$P_c = \frac{\pi D_G}{T_G} = \frac{\pi(8\,in)}{30\ teeth} = 0.8378$$

Substi

$$P_{cn} = (0.8378)(\cos 23°)$$

$$\boxed{P_{cn} = 0.7712}$$

$$P_d = \frac{T}{D} = \frac{20 \text{ teeth}}{10 \text{ in}}$$

$$P_d = 2$$

# 7 to 8

$$\varepsilon = \tan\alpha\left[\frac{\cos\theta - f\tan\alpha}{\cos\theta\tan\alpha + f}\right]$$

$$\tan\alpha = \frac{L}{\pi D_W} = \frac{3p}{\pi D_W}$$

$$\tan\alpha = \frac{3(1.75\text{ in})}{\pi(5.25\text{ in})} = 0.3183$$

substi

$$\varepsilon = 0.3183\left[\frac{\cos 14.5° - (0.030)(0.3183)}{(\cos 14.5)(0.3183) + 0.030}\right]$$

$$\varepsilon = 90.23\,\%$$

$$C = \frac{D_W + D_G}{2} \quad ; \quad p_c = \frac{\pi D_G}{T_G}$$

$$1.75\text{ in} = \frac{\pi D_G}{56}$$

$$D_G = 31.1944\text{ in}$$

substi

$$C = \frac{(5.25 + 31.1944)\text{in}}{2}$$

$$C = 18.2222\text{ in}$$

$$\varepsilon = \tan\alpha \left[ \frac{\cos\theta - f\tan\alpha}{\cos\theta \tan\alpha + f} \right]$$

Using Given Choices

$$= \tan 26.5° \left[ \frac{\cos 14.5° + (0.20)\tan 26.5°}{(\cos 14.5°)(\tan 26.5°) + 0.20} \right]$$

$$\varepsilon = 77.99\%$$

$$\varepsilon = \tan\alpha \left[ \frac{\cos\phi - f\tan\alpha}{\cos\phi \tan\alpha + f} \right]$$

$$\tan\alpha = \frac{L}{\pi D w} = \frac{3P}{\pi D w} = \frac{3(0.7\pi\ in)}{\pi(3\ in)} = 0.2387$$

Substi

$$\varepsilon = 0.2387 \left[ \frac{\cos 14.5^\circ - (0.12)(0.2387)}{(\cos 14.5^\circ)(0.2387) + 0.12} \right]$$

$$\varepsilon = 63.88\%$$

Pitch line velocity of Gear

$$v_G = \pi D_G N_G \quad ; \quad VR = \frac{T_G}{T_W}$$

$$8 = \frac{T_G}{3}$$

$$T_G = 24 \text{ teeth}$$

and;

$$P_d = \frac{T_G}{D_G}$$

$$5_{in} = \frac{24 \text{ teeth}}{D_G}$$

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

and;

$$VR = \frac{N_W}{N_G}$$

$$8 = \frac{650 \text{ rpm}}{N_G}$$

$$N_G = 81.25 \text{ rpm}$$

Hence;

$$v_G = \pi (4.8 \text{ in}) \left(\frac{81.25 \text{ rpm}}{60}\right) \left(\frac{1 \text{ ft}}{12 \text{ in}}\right)$$

$$v_G = 1.7017 \text{ ft/sec}$$

Linear Velocity of worm

$$V = LN_w$$

$$\tan\alpha = \frac{L}{\pi D_w}$$

$$\psi + \alpha = 90°$$

$\psi$ = Helix angle

$\alpha$ = Lead angle

$$83° + \alpha = 90°$$

$$\alpha = 7°$$

Substi;

$$\tan 7° = \frac{L}{\pi(5.75\,in)}$$

$$L = (2.2180\,in)\left(\frac{1\,ft}{12\,in}\right) = 0.1848\,ft$$

Hence;

$$V = (0.1848\,ft)\left(820\,\frac{rev}{min}\right)$$

$$\boxed{V = 151.5633\,\frac{ft}{min}}$$

$$C = \frac{D_W + D_G}{2} \; ; \quad P_C = \frac{\pi D_G}{T_G}$$

$$0.75\,in = \frac{\pi D_G}{24\ teeth}$$

$$D_G = 5.7296\ in$$

from;

$$\frac{D_G}{D_W} = \frac{T_G}{T_W}$$

$$\frac{5.7296\ in}{D_W} = \frac{24\ teeth}{3\ thread}$$

$$D_W = 0.7162\ in$$

Hence;

$$C = \frac{(0.7162 + 5.7296)\ in}{2}$$

$$C = 3.2229\ in$$

$$P_c = \frac{\pi D_G}{T_G}$$

$$1\ \text{in} = \frac{\pi D_G}{42\ \text{teeth}}$$

$$D_G = 13.3690\ \text{in}$$

$$\frac{N_W}{N_G} = \frac{T_G}{T_W}$$

$$\frac{1200\ \text{rpm}}{N_G} = \frac{32\ \text{teeth}}{3\ \text{thread}}$$

$$N_G = 112.5\ \text{rpm}$$

$$\tan\alpha = \frac{L}{\pi D_w} = \frac{3P}{\pi D_w}$$

$$\tan\alpha = \frac{3(0.75\ in)}{\pi(3.75\ in)}$$

$$\alpha = 10.8125°$$

Hence;

$$\psi + \alpha = 90°$$

$$\psi + 10.8125° = 90°$$

$$\psi = 79.1875° \quad (\text{Helix angle})$$

$$\psi + \alpha = 90°$$
$$82° + \alpha = 90°$$
$$\alpha = 8°$$

and;

$$\tan\alpha = \frac{L}{\pi D_w} = \frac{3P}{\pi D_w}$$

$$\tan 8° = \frac{3(3/4\ \text{in})}{\pi D_w}$$

$$\boxed{D_w = 5.0960\ \text{in}}$$

$$\tan\alpha = \frac{L}{\pi D_w} = \frac{2P}{\pi D_w}$$

$$\tan 6° = \frac{2P}{\pi(2)(2.25\,in)}$$

$$P = 0.7429\,in$$

$$P = \tfrac{3}{4}\,in$$

$$P = 2\pi T N$$

$$(12\,hp)\left(\frac{550\ \frac{ft\text{-}lb}{sec}}{1\,hp}\right) = \frac{2\pi T\,(1200\ rpm)}{60}$$

$$T = 65.6514\ ft\text{-}lb$$

and;

$$T = F_t r$$

$$65.6514\ ft\text{-}lb = F_t \left(\frac{3.5\,in}{2}\right)\left(\frac{1\,ft}{12\,in}\right)$$

$$F_t = 450.1811\ lb$$

Dedendum Angle of the Gear

$$\delta_2 = \tan^{-1}\left(\frac{b}{L}\right)$$

(dedendum of Gear) $\quad b = \frac{1.5571}{P} = \frac{1.5571}{4} = 0.3893 \text{ in}$

(cone distance of pinion) $\quad L = \frac{D_1}{2\sin\gamma_1}$

$$\gamma_1 = \tan^{-1}\left(\frac{N_2}{N_1}\right) = \tan^{-1}\left(\frac{1}{2}\right)$$

$$\gamma_1 = 26.5650°$$

$$L = \frac{8 \text{ in}}{2\sin 26.5650°} = 8.9443 \text{ in}$$

Hence;

$$\delta_2 = \tan^{-1}\left(\frac{0.3893 \text{ in}}{8.9443 \text{ in}}\right)$$

$$\boxed{\delta_2 = 2.4948°}$$

Addendum Angle of the pinion

$$\alpha_1 = \tan^{-1}\left(\frac{a}{L}\right)$$

(addendum of pinion) $$a = \frac{1.4}{P} = \frac{1.4}{5} = 0.28\text{-in}$$

(cone distance of pinion) $$L = \frac{D_1}{2\sin\gamma_1}$$

$$\gamma_1 = \tan^{-1}\left(\frac{N_2}{N_1}\right) = \tan^{-1}\left(\frac{1}{4}\right)$$

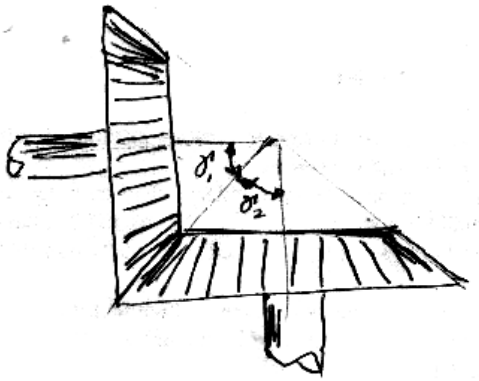
$$\gamma_1 = 14.0362^\circ$$

$$L = \frac{7\text{in}}{2\sin(14.0362^\circ)} = 14.4309\text{in}$$

Hence,

$$\alpha_1 = \tan^{-1}\left(\frac{0.28\text{in}}{14.4309\text{in}}\right)$$

$$\boxed{\alpha_1 = 1.1116^\circ}$$




$$L_1 = L_2$$

$$\frac{D_1}{2\sin\gamma_1} = \frac{D_2}{2\sin\gamma_2}$$

$$\frac{D_2}{D_1} = \frac{N_1}{N_2} = \frac{\cancel{2}\sin\gamma_2}{\cancel{2}\sin\gamma_1}$$

$$VR = \frac{\sin(69°)}{\sin(24°)}$$

$$VR = 2.2098$$

$$\tan \gamma_1 = \frac{N_2}{N_1}$$

$$\tan 32^\circ = \frac{N_2}{280\ \text{rpm}}$$

$$N_2 = 174.9634\ \text{rpm}$$

$$P = 2\pi T N$$

$$(5\,hp)\left(\frac{550\ \frac{ft\text{-}lb}{sec}}{1\,hp}\right) = 2\pi T\left(\frac{1300\,rpm}{60}\right)$$

$$T = 20.20\ ft\text{-}lb$$

Hence;

$$T = F_t\, r$$

$$20.20\ ft\text{-}lb = F_t\left(\frac{4\,in}{2}\right)\left(\frac{1\,ft}{12\,in}\right)$$

$$F_t = 121.2026\ lbs$$

$$\tan \gamma_1 = \left(\frac{N_2}{N_1}\right) = \frac{1}{3}$$

$$\gamma_1 = 18.434^9 9^\circ$$

$$\tan \gamma_1 = \left(\frac{N_2}{N_1}\right) = \frac{1}{2}$$

$$\gamma_1 = 26.5651^\circ$$

$$T = F_t r$$

$$D_m = D - f \sin\phi$$

$$= 15\text{ in} - (5\text{ in})(\sin 40^\circ)$$

$$D_m = 11.7861\text{ in}$$

subst:

$$8200\text{ in-lb} = F_t \left(\frac{11.7861\text{ in}}{2}\right)$$

$$F_t = 1391.4741\text{ lbs}$$

$$D_m = D - 2f \sin\gamma$$

$$= 13\text{ in} - (3.75\text{ in}) \sin 38°$$

$$D_m = 10.6913\text{ in}$$