ME 354 Fall 2022: Quiz 8 Name: Solution

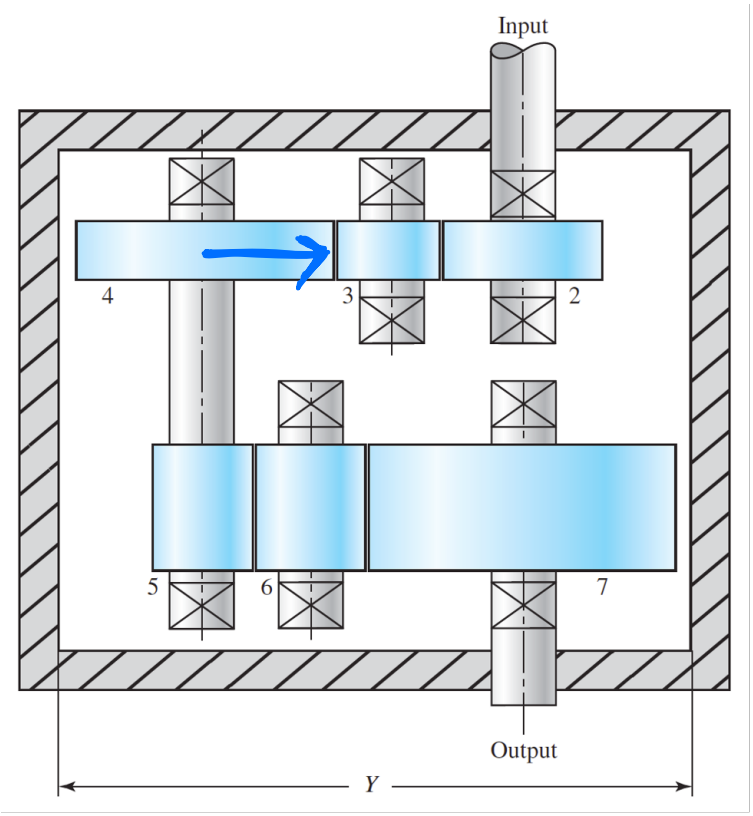
INSTRUCTIONS:

This quiz is open-book, open-note, and you may work with your classmates.

GIVEN:

In the gearbox shown, gears 4 and 5 are compounded on the same shaft. The gearbox receives input power of 4 hp at a speed of 300 rpm.

The gears have a diametral pitch of 6 teeth/in, a 20° pressure angle, and teeth numbers $N_2 = 30$, $N_3 = N_5 = 20$, $N_4 = 60$, and $N_7 = 80$.



FIND:

a) The number of teeth on gear 6 to make the gearset a compound reverted gearset.

b) The gear train ratio.

c) The output speed, in rpm.

d) The pitch line velocity for gear 2, V, in units of ft/min.

e) The transmitted load between gears 2 and 3, W^t, in lbf.

f) The radial load supported by the input shaft in lbf.

g) The input and output torques, in lbf-ft.

h) The output power, in hp.

a) for compound reverted gearset, the input and output shafts must be aligned

$$\rightarrow \frac{d_2}{2} + d_3 + \frac{d_4}{2} = \frac{d_5}{2} + d_6 + \frac{d_7}{2}$$

$$\frac{N_2}{2} + N_3 + \frac{N_4}{2} = \frac{N_5}{2} + N_6 + \frac{N_7}{2}$$

($N_2 = 30$, $N_3 = 20$, $N_4 = 60$, $N_5 = 20$, $N_7 = 80$)

$N_6 = 15$ teeth

b) $\omega_3 = -\frac{N_2}{N_3}\omega_2$

$\omega_4 = -\frac{N_3}{N_4}\omega_3 = +\frac{N_2}{N_3}\frac{N_3}{N_4}\omega_2$ → gear 3 is an idler

$\omega_5 = \omega_4 = +\frac{N_2}{N_4}\omega_2$

$\omega_6 = -\frac{N_5}{N_6}\omega_5 = -\frac{N_5}{N_6}\frac{N_2}{N_4}\omega_2$

$\omega_7 = -\frac{N_6}{N_7}\omega_6 = +\frac{N_6}{N_7}\frac{N_5}{N_6}\frac{N_2}{N_4}\omega_2$ → gear 6 is an idler

$\frac{\omega_7}{\omega_2} = +\frac{N_5 N_2}{N_7 N_4} = \frac{20 \cdot 30}{80 \cdot 60} = \frac{1}{8}$ → output speed is 1/8 the input speed... or output torque is 8x the input torque.

- alternatively -

$\frac{\#\text{ of driving}}{\#\text{ of driven}} = +\frac{N_2 N_3 N_5 N_6}{N_3 N_4 N_6 N_7}$

↑ even # of meshes (4)

c) $\omega_1 = \frac{1}{8}\omega_2 = \frac{1}{8} \cdot 300 \text{ rpm} = 37.5 \text{ rpm}$

d) from AGMA roadmaps $V = \frac{\pi d n}{12}$

where d is in inches and n is in rpm

$$d_2 = \frac{N_2}{P_d} = \frac{30 \text{ teeth}}{6 \text{ teeth/in}} = 5 \text{ in}$$

$$V = \frac{\pi \cdot 5 \text{ in} \cdot 300 \text{ rpm}}{12} = 392.7 \text{ ft/min}$$

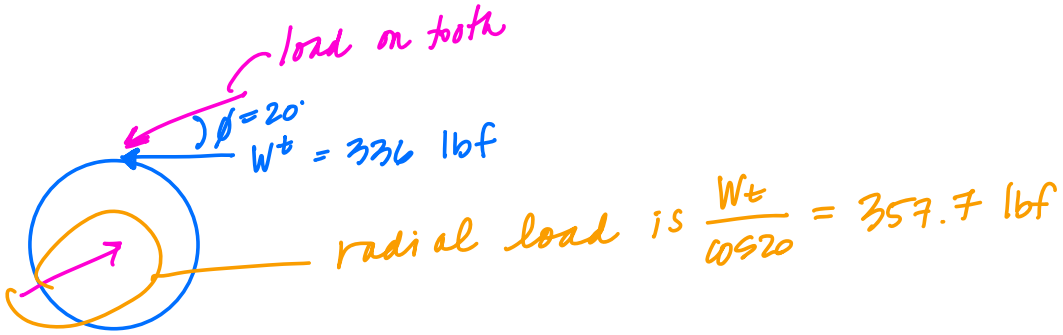
-or- $V = \omega r = 300 \frac{\text{rev}}{\text{min}} \cdot 2.5 \text{ in} \cdot \frac{2\pi \text{ rad}}{\text{rev}} \cdot \frac{1 \text{ ft}}{12 \text{ in}} = 392.7 \text{ ft/min}$

e) $W^t = \frac{33000\, H}{V}$ from AGMA roadmaps

where H is in hp and V is in ft/min

$$W^t = \frac{33000 \cdot 4 \text{ hp}}{392.7 \text{ ft/min}} = 336 \text{ lbf}$$

f)



g) power is conserved through the gearset

→ output power is 4 hp.