RBE 1001 Homework #6 **Name: Solution**__________________________

Problem statement:

Your robot requires 6.0 inch diameter driven wheels which must have at least 1.0 inch clearance from the final drive gear to the ground. *(Note: the outside diameter (d_{OD}) of a gear equals the pitch diameter (d_p) plus 2÷ diametral pitch (P), with answer in inches. Recall that diametral pitch "P" equals N÷ d_p where N is # of teeth.)*

$$IE: d_{OD} = d_p + 2/P; \quad P = N/d_p$$

You desire a single stage spur gear reduction from the motor to the drive gear. Your load calculations indicate you must use 20 pitch/20º pressure angle gears and you will use a 15T pinion gear (on the motor output).

1) To get the *smallest "e" possible (ie: max torque output*) while maintaining the required ground clearance, what size (number of teeth) gear would you have on your wheel axle? (ans~75T)

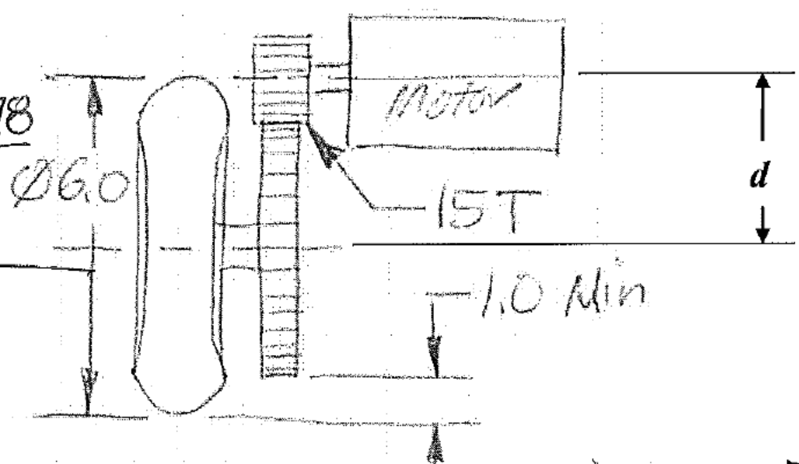
2) What is the **exact** offset distance (***D***) between the motor centerline and the wheel axle centerline? (Note the centerline of the pinion does *not* line up with

2) $D_p = \frac{N}{P}$

so...

$d = \frac{D_{P15}}{2} + \frac{D_{P78}}{2} = \frac{15+78}{40}$

$= \boxed{2.325\text{in}}$



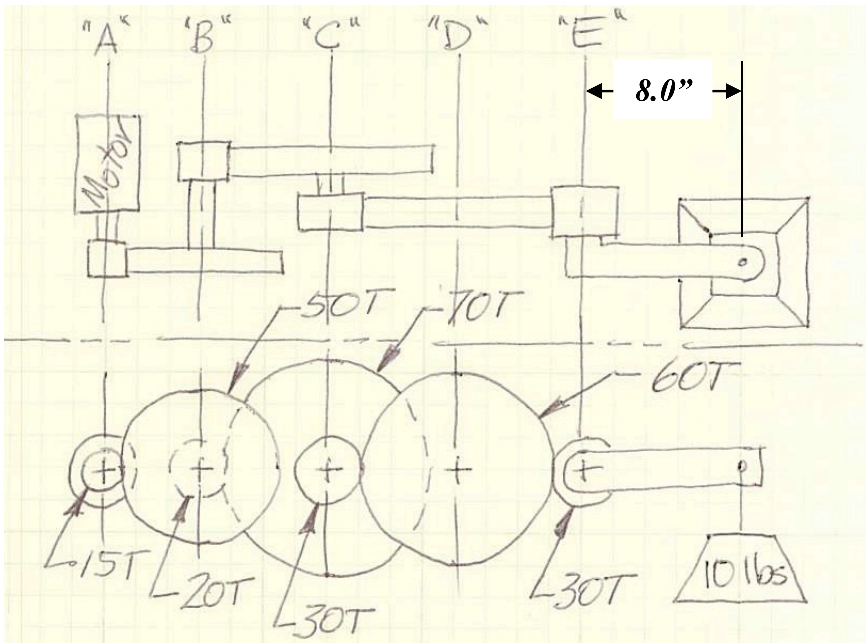
1) Max Gear Radius $= \frac{6.0}{2} - 1 = 2.0\text{in}$ ∴ Max O.D. $= 4.0\text{in}$

Per note above: O.D. $= D_p + \frac{2}{20} = 4.0$; By defn: $D_p = \frac{N}{P}$

$\Rightarrow 4 = \frac{N}{20} + \frac{2}{20} \Rightarrow N = 3.9(20) = \boxed{78T}$

$e = \frac{N_{DRR}}{N_{DRY}} = \frac{15}{78} = \boxed{.19}$

This robot also has an arm as shown below with a complex multi-stage gear transmission. When lifting the weight in the condition shown, you note that the arm motor (at shaft A) is turning 100 rpm. Recall that the geartrain, “e” (aka “speed ratio”), of a gear set equals the product of the number of teeth on all “driving” gears divided by the product of the number of teeth on all “driven” gears. Drivers are defined as gears that convert applied shaft torque to force at the pitch diameter. Likewise, driven gears convert this applied force to output shaft torque.



(Note: The sketch above shows a top and side view of the same arrangement. The output gear (30T) that is at shaft "E" is connected to an arm that, in the position shown (horizontal), has a moment arm of 8 inches.

3) What is the rotation speed of the arm (shaft E)? (ans~9 rpm)

$e = N_{drvr} / N_{drvn} = (15 \times 20 \times 30) / (50 \times 70 \times 30) = 0.0857 = n_{out} / n_{in}$ So $n_{out} = 0.0857 \times 100 = 8.6$ RPM

4) What is the effect of the gear at shaft D on the overall “e”?

No effect on e from an idler gear. Reverses direction and lowers efficiency.

5) Given a gear stage efficiency (η) of .95, how much torque must the motor provide to steadily raise the load at the instance shown in the sketch? (ans~8inlbs)

$e = 0.0857 = (T_{in} / T_{out}) \times \eta$. $T_{out} = F \times d = 8$ in x 10 lbs = 80 in-lbs.

$T_{in} = e\,T_{out} / \eta = 0.0857 \times 80 / 0.95^4 = 8.3$ in-lbs. 0.95^4 because there are 4 stages including the idler.