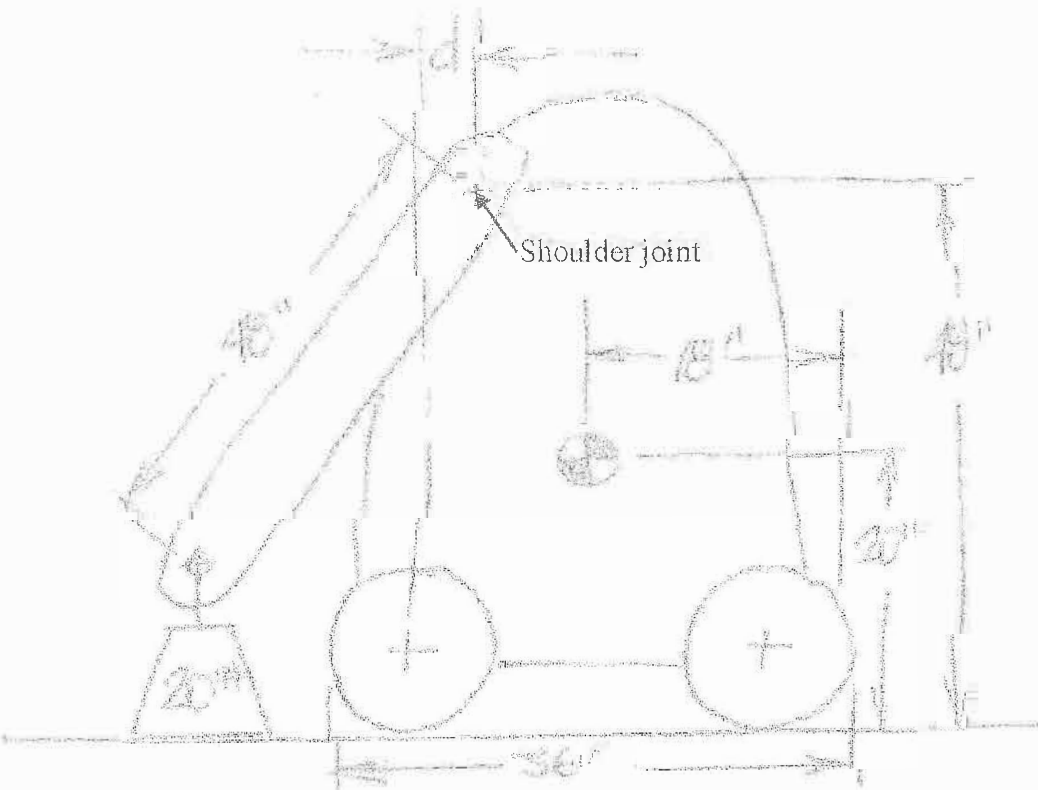
RBE 1001 Homework 10 **Name:** Solutions

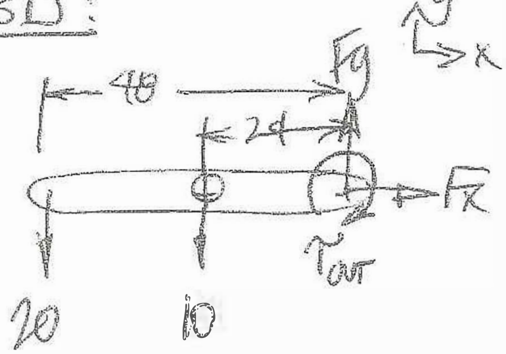
Problem statement:

Your 4-wheeled robot with 14 in wheels needs to pick up a 20 lb weight from ground level and raise it to 6 ft. You are provided a motor that is rated for *continuous* torque output of 228 in-lbs and stalls at 310 in-lbs. The center of gravity of the robot chassis is as shown; it weighs 100 lbs. The arm weighs an additional 10 lbs with a center of gravity midway along its length. You will rotate the arm around the shoulder joint using a single strand of either #25 or #35 roller chain and appropriate sprockets; you have 12T sprockets available in both sizes.



1) Draw a FBD of the **loaded arm** and use the EofE to determine the ***maximum*** moment/ torque (…at what arm angle would that occur?) required at the shoulder joint to do the lift. (Ans: ~1250 in-lbs)

FBD:



EofE:

$$\Sigma M_{z+} = 10(24) + 20(48) - T_{OUT}$$

$$\therefore T_{OUT} = \boxed{1200 \text{ in lb}}$$

(#3 cont)

#25 strength w/ quicklink

$875 \times .75 = 656\text{ lb} < 1300$

#35 strength w/ quicklink

$2100 \times .75 = 1575\text{ lb} > 867$

$\therefore$ $\boxed{\text{use \#35}}$

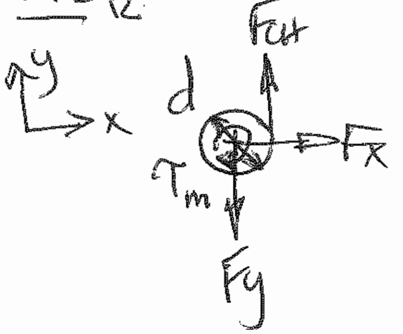
2) What is the overall speed reduction (ie "e") required? If accomplished in a single stage (ie 2 sprockets and 1 chain) and you use one of the 12T sprockets you have, how many teeth must be on the second sprocket? (Note: Sprockets may be specified with any *integer* number of teeth.) (Ans: ~70T)

$$e = \frac{T_{IN}}{T_{OUT}}\eta = \frac{228}{1200}(.95) = \boxed{.18}$$

$$= \frac{N_{DRIVER}}{N_{DRIVEN}} = \frac{12}{N} = .18 \therefore N = \boxed{67T}$$

3) Compute the *maximum* static chain load for the system using #25 and #35 chains/ sprockets (assume that the arm becomes blocked such that the motor stalls). If you desire a safety factor of 2 and intend to use a master link* in the chain, which chain size would you recommend for the minimum weight configuration? (*Note: Master links, aka "quick links", provide easy disassembly of chains but are only rated at 75% of the chain's intrinsic strength.)

FBD_{12}:



EoE:

$$\Sigma M_{Z+} = 0 = F_{CH}\left(\frac{d}{2}\right) - T_m$$

$$\therefore F_{CH_{25}} = 649, \quad \times 2 \text{ (safety factor)} = 1300\text{ lb}$$

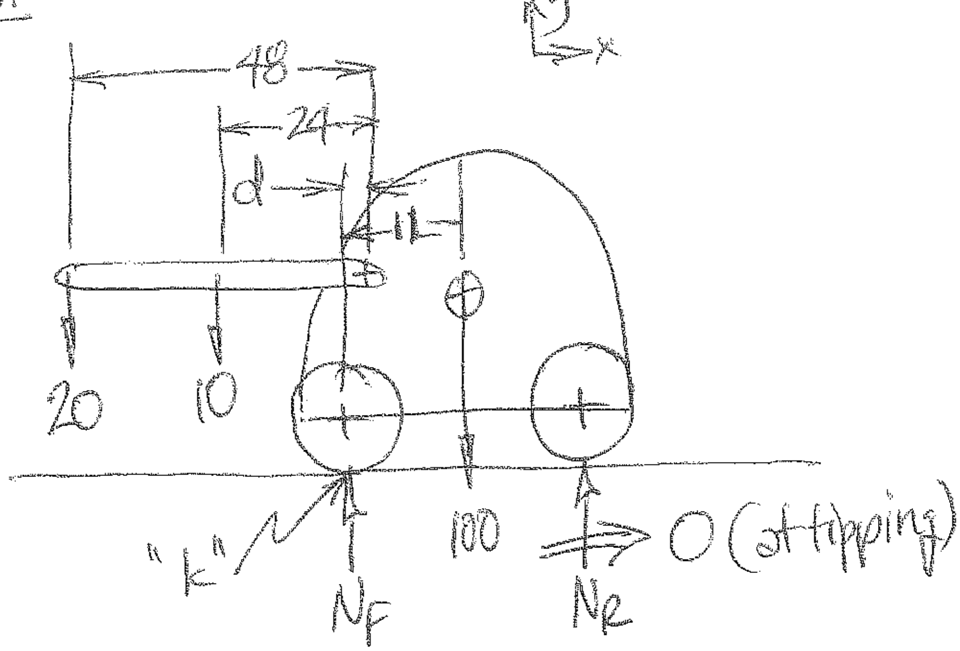
$$F_{CH_{35}} = 434, \quad \text{''} \quad = 867\text{ lb}$$

$T_m = 228$

$$d = \frac{(\text{pitch})12T}{\pi} \begin{cases} \text{for \#25: } \frac{\frac{2}{8}(12)}{\pi} = .955\text{ in} \\ \text{for \#35: } \frac{\frac{3}{8}(12)}{\pi} = 1.43\text{ in} \end{cases}$$

4) Draw a **FBD** of the robot plus loaded arm and use the **EofE** to determine the minimum "d" to prevent the robot from tipping over when lifting the weight from the ground to 6 ft. Assume that the robot is on level ground. (Ans: ~3in)

FBD:



EofE:

$$\sum M_{z_K} = 0 = (-100)11 + 10(24-d) + 20(48-d)$$

$$30d = 1200 - 1100$$

$$d = \boxed{3.33\text{ in}}$$