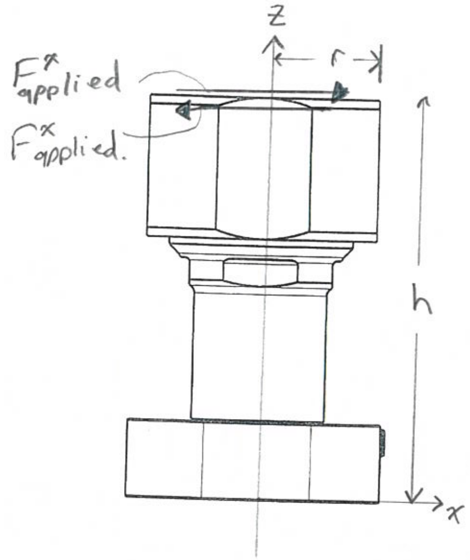
# Free-Body Diggram (FBD)
# Ideal Loading Condition of Spanner Nut Utilizing Force Couples




## Statics

**Sum of Forces**

$$\Sigma F_x = F^x_{app} - F^x_{app} = 0$$

$$\Sigma F_y = 0$$

$$\Sigma F_z = 0$$

**Sum of Moments or Torques**

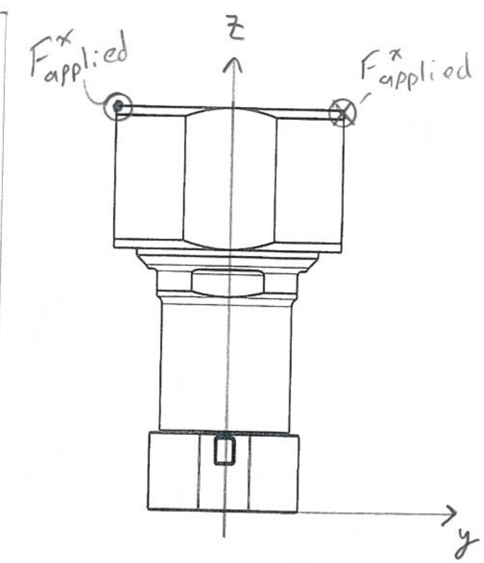
$$\Sigma M_x = 0$$

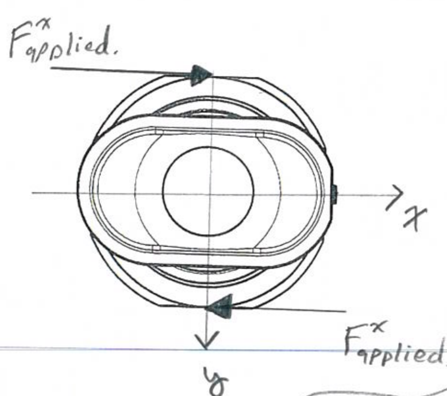
$$\Sigma M_y = F^x_{app} \cdot h - F^x_{app} \cdot h + M_y = 0.$$

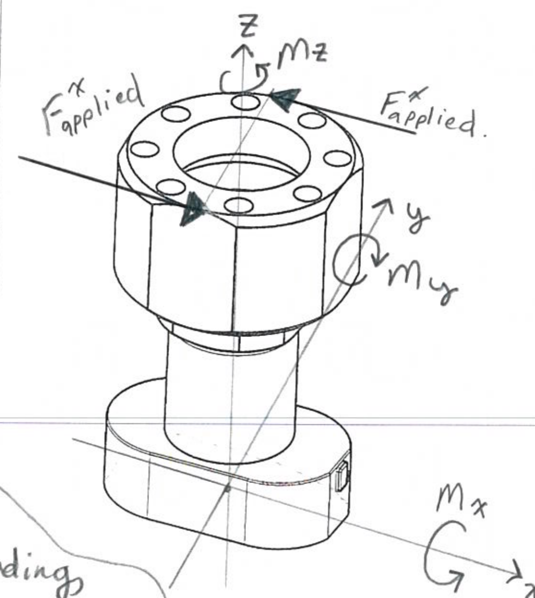
$$\boxed{M_y = 0}$$

$$\Sigma M_z = M_z - F^x_{app} \cdot r - F^x_{app} \cdot r = 0.$$

$$\boxed{M_z = 2 \cdot r \, F^x_{app}}$$



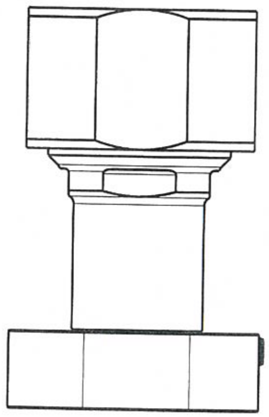




Conclusion: A Force Couple load results in a zero bending pure torque load on the spanner nut($M_z$).

Neal Gordon
6/24/2014
Noble Tek

FBD of Actual loading conditions for <u>all</u> current Designs of Noble Tek
(see page 1 for definitions)



Sum of Forces

$$\Sigma F_x = F^x_{app} - F^x_r = 0$$

$$F_{app}^x = F^x_r$$

$$\Sigma F_y = 0$$

$$\Sigma F_z = 0$$

Sum of Moments

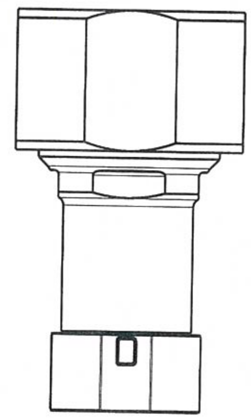
$$\Sigma M_x = 0$$

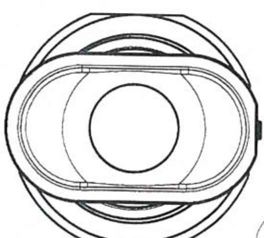
$$\Sigma M_y = F^x_{app} \cdot h + M_y = 0$$

$$\boxed{M_y = F^x_{app} \cdot h}$$

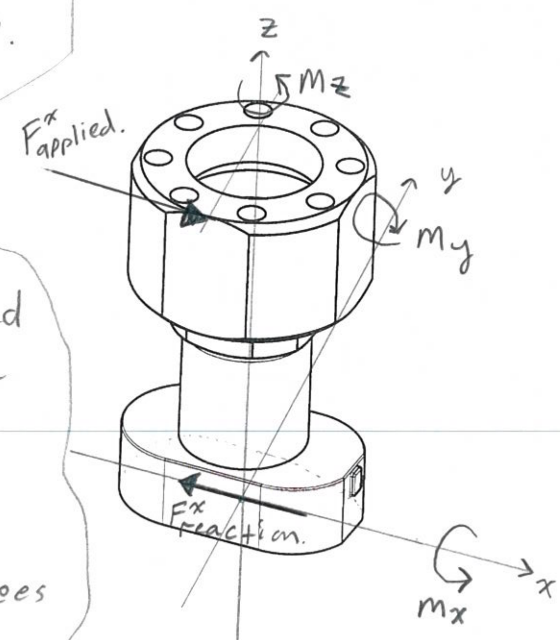
$$\Sigma M_z = F^x_{app} \cdot r + M_z = 0.$$

$$\boxed{M_z = F^x_{app} \cdot r}$$





Conclusion: A shear load in $x$ direction and a bending moment about $y$ must be isolated with a fixture to constrain <u>all</u> 6 degrees of freedom




Neal Gordon
6/24/2014
Noble Tek

# NobleTeK Design 1 & 2 calculations

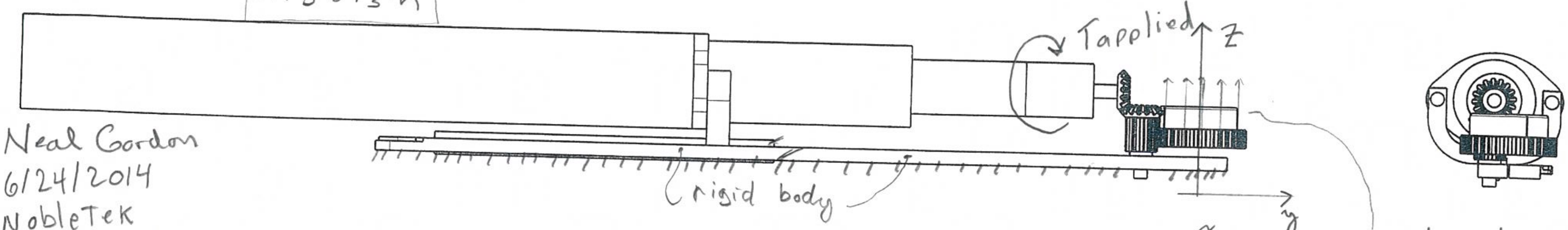
Assumptions: ① Assume male fitting fixture is a rigid body
② Assume fixture fully constrains all 6 dof of the fitting, thus male fitting is also a rigid Body.

---

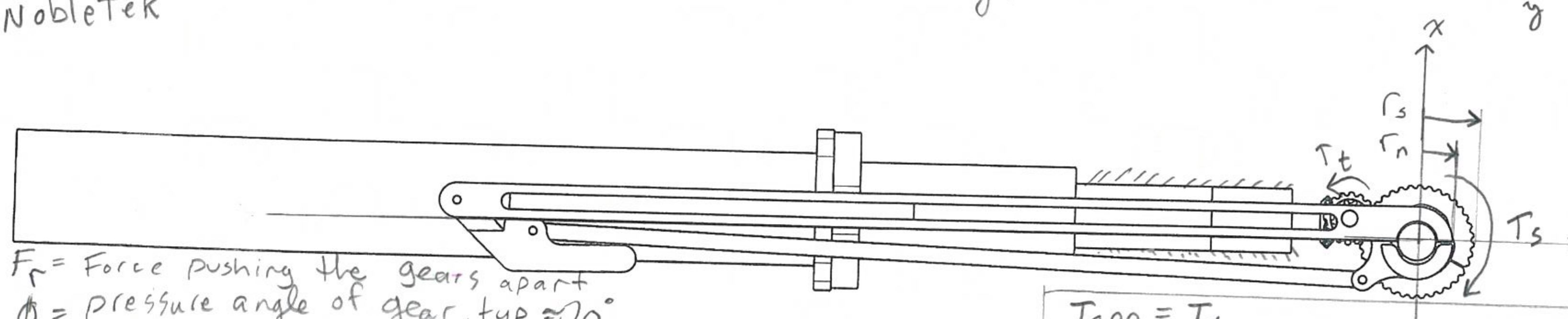
Conclusion: Bending moments are caused by the tangential Force ($F_s$) and radial force ($F_r$) gears. It is assumed that the bending is held by the clamp, thus as long as assumption ① is correct, it is negligible.

$$\boxed{\begin{aligned} M_x &\approx F_r \cdot h \\ M_y &\approx F_s \cdot h \end{aligned}}$$

Neal Gordon
6/24/2014
NobleTeK




* As the spanner nut rotates it will travel in $z^+$ and freely slide on the spur gear.

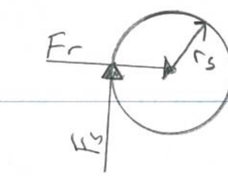



$F_r$ = Force pushing the gears apart
$\phi$ = pressure angle of gear, typ ≈ 20°
$n_s$ = # teeth of the spanner gear = 36
$n_t$ = # teeth of transfer gear = 12
$r_s$ = pitch radius of spanner gear = 25 mm
$r_n$ = radius of spanner nut = 13 mm
$T_t$ = torque transfor gear
$T_s$ = torque of spanner gear
$F_s$ = Tangential Force on spanner gear
$F_n$ = Tangential Force on Spanner nut

$T_{app} = T_t$

$$T_t \cdot \frac{n_s}{n_t} = T_s$$

$$F_r = F_s \tan\phi$$




<u>Tangential Forces</u>

$$T_s = F_s \cdot r_s = F_n r_n$$

$$F_n = \frac{T_s}{r_n}$$

$$\boxed{F_n = \frac{1}{r_n} \cdot T_t \cdot \frac{n_s}{n_t}}$$

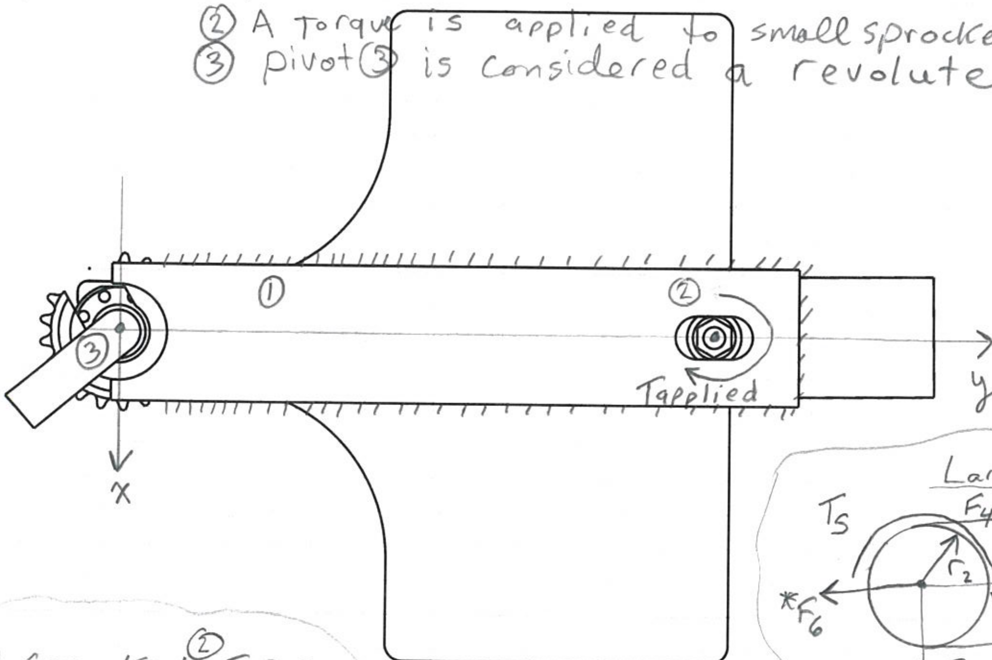
→ use calculations from page 2

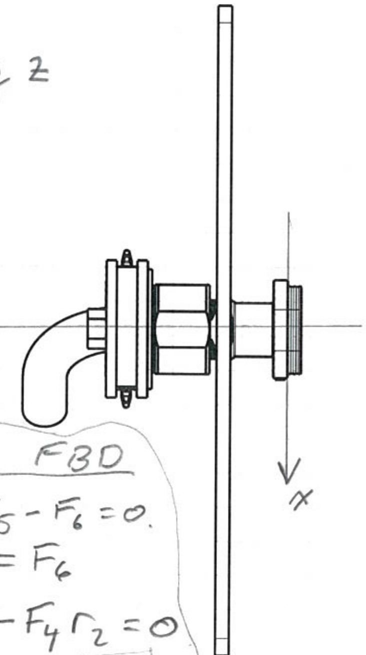
Page 4

## Calculations for LG Fixture & Torquing design

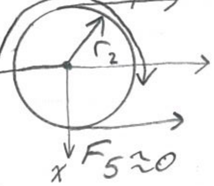
Assumptions: ① plate is rigidly secured to external frame
② A Torque is applied to small sprocket directly.
③ pivot ③ is considered a revolute joint along z

$T_s$ = Torque on sprocket




### Large Sprocket + ③ FBD




$\Sigma F_y = F_4 + F_5 - F_6 = 0.$

$F_4 = F_6$

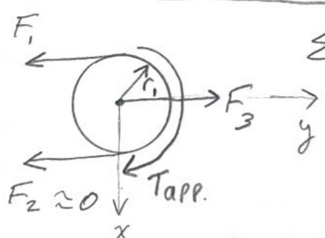
$\Sigma M_z = -T_s - F_4 r_2 = 0$

$\boxed{T_s = -F_4 r_2}$

$*F_6$ is supported by plate ①

$F_1 = -F_4$

### Small Sprocket + ② FBD




$\Sigma F_y = F_3 - F_1 - F_2 = 0.$

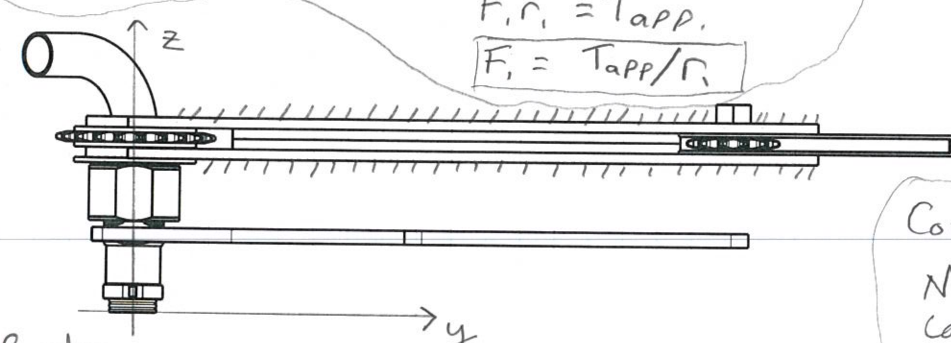
$F_2 \approx 0$

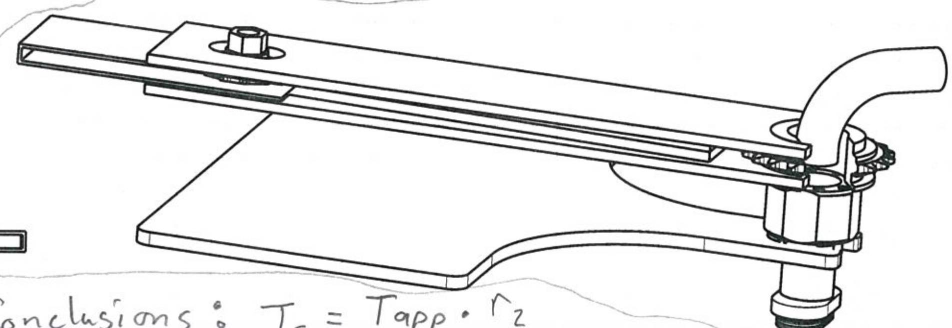
$F_3 = F_1$ ($F_3$ supported by plate ①)

$\Sigma M_z = F_1 r_1 - T_{app} = 0.$

$F_1 r_1 = T_{app}.$

$\boxed{F_1 = T_{app}/r_1}$



Conclusions: $T_s = T_{app} \cdot \frac{r_2}{r_1}$

No Bending in fitting due to revolute joint constraining motion to rotation about z.
Does Not allow for vertical travel in z when spanner nut is thread

Neal Gordon
6/24/2014
NobleTek