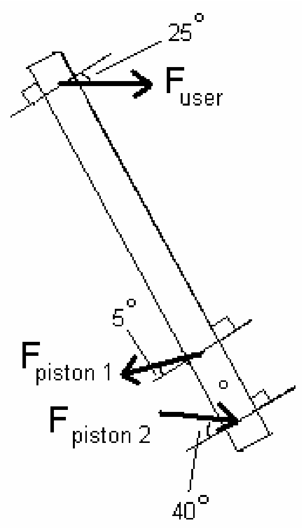
Appendix J



(positive clockwise):

$\Sigma M_p = F_{user}(\cos 25°)(2.92) – F_{pistion1}(\cos 5°)(.333) – F_{piston2}(\cos 40°)(.417) = 0$

$F_{user\ min}$: F_{user} will be minimum when each of the pistons is set on the lowest setting, 5 lbs.

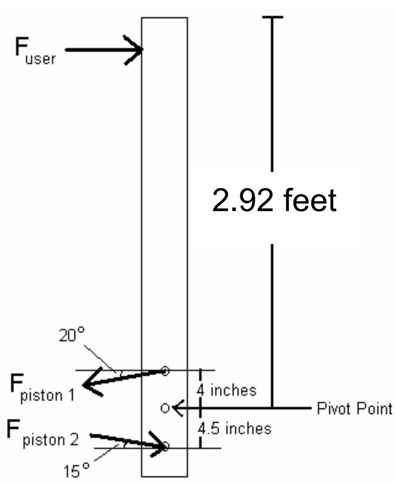
$F_{user\ min}(\cos 25°)(2.92\ ft)-(5\ lb)(\cos 5°)(.417\ ft)-(5\ lb)(\cos 40°)(.333\ ft) = 0$

$F_{user\ min} = 3.70$ lbs

$F_{user\ max}$: F_{user} will be maximum when $F_{piston1}$ is set on the maximum setting, 200 lbs ($F_{piston2}$ is being shortened and can therefore only produce 5 lbs force).

$F_{user\ max}(\cos 25°)(2.92\ ft)-(200\ lb)(\cos 5°)(.417\ ft)-(5\ lb)(\cos 40°)(.333\ ft) = 0$

$F_{user\ max} = 93.08$ lb



(positive clockwise):

$\Sigma M_p = F_{user}(2.92\ ft) – F_{pistion1}(\cos 18.4°)(.333\ ft) – F_{piston2}(\cos 15°)(.417\ ft) = 0$

$F_{user\ min}$: F_{user} will be minimum when each of the pistons is set on the lowest setting, 5 lbs.

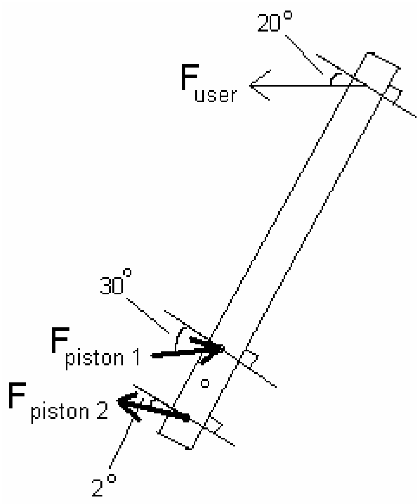
$F_{user\ min}(2.92\ ft) – (5\ lb)(\cos 18.4°)(.417\ ft) – (5\ lb)(\cos 15°)(.333\ ft) = 0$

$F_{user\ min} = 3.59$ lbs

$F_{user\ max}$: F_{user} will be maximum when $F_{piston1}$ is set on the maximum setting, 200 lbs ($F_{piston2}$ is being shortened and can therefore only produce 5 lbs force).

$F_{user\ max}(\cos 25°)(2.92\ ft)-(200\ lb)(\cos 18.4°)(.417\ ft)-(5\ lb)(\cos 15°)(.333\ ft) = 0$

$F_{user\ max} = 80.74$ lb

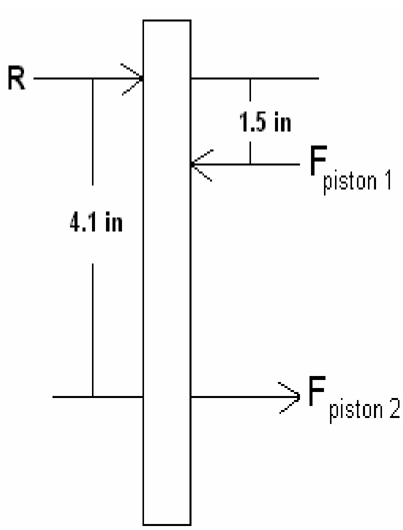


(positive clockwise):
$\Sigma M_p = F_{user}(\cos 20°)(2.92\text{ ft}) – F_{pistion1}(\cos 30°)(.333\text{ ft}) – F_{piston2}(\cos 2°)(.417\text{ ft}) = 0$

$F_{user\ min}$: F_{user} will be minimum when each of the pistons is set on the lowest setting, 5 lbs.
$F_{user\ min}(2.92\text{ ft}) – (5\text{ lb})(\cos 30°)(.417\text{ ft}) – (5\text{ lb})(\cos 2°)(.333\text{ ft}) = 0$
$F_{user\ min} = 3.68$ lbs

$F_{user\ max}$: F_{user} will be maximum when $F_{piston2}$ is set on the maximum setting, 200 lbs ($F_{piston1}$ is being shortened and can therefore only produce 5 lbs force).

$F_{user\ max}(\cos 25°)(2.92\text{ ft})-(200\text{ lb})(\cos 30°)(.417\text{ ft})-(5\text{ lb})(\cos 2°)(.333\text{ ft}) = 0$
$F_{user\ max} = 72.75$ lb



(positive clockwise):
Fpiston1 is at an angle of 5° above the horizontal and Fpiston2 is at an angle of 22° below the horizontal.

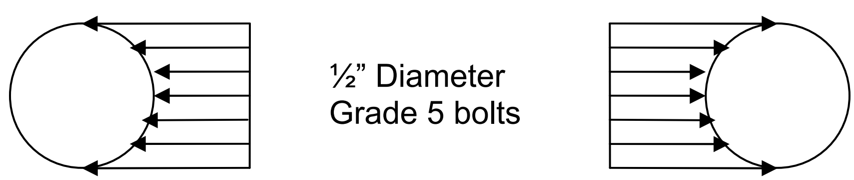
$\Sigma M_R = F_{piston1}(1.5\text{ in})(\cos 5°) – F_{piston2}(4.1\text{ in})(\cos 22°)$

The maximum torque will on the bolt will occur when Fpiston2 is set to the maximum resistance (Fpiston1 is being shortened and can therefore only produce 5 lbs force).

$\Sigma M_R = (5\text{ lb})(1.5\text{ in})(\cos 5°) – (200\text{ lb})(4.1\text{ in})(\cos 22°) = 62.75$ lb*inch

Since there is a larger component of force in the horizontal direction than in the vertical direction, the torque exerted in the vertical direction must be less than 62.75 lb and therefore does not need to be calculated.

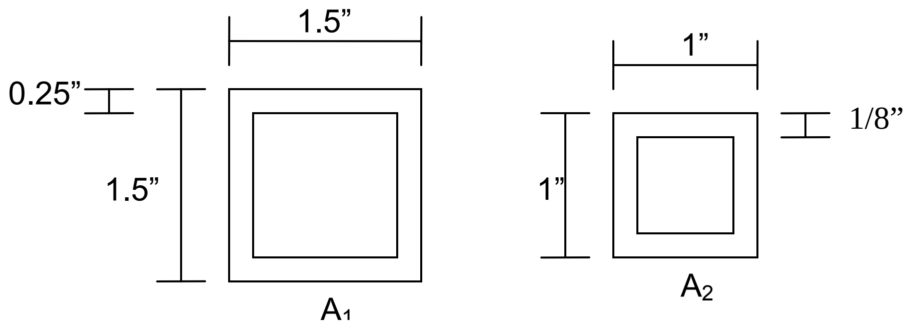
Shear on bolt:



V = 500 lbs   V = 500 lbs

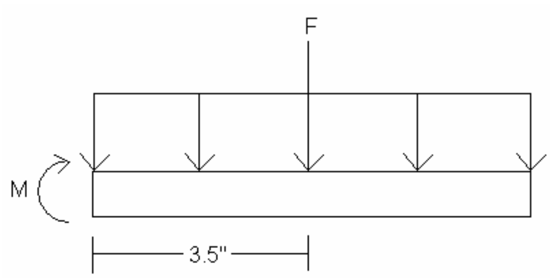
$\tau = V/A = (500\text{ lb}/2)/(\Pi(1/4)^2) = 2546\text{ psi}/2 = 1273\text{ psi}$

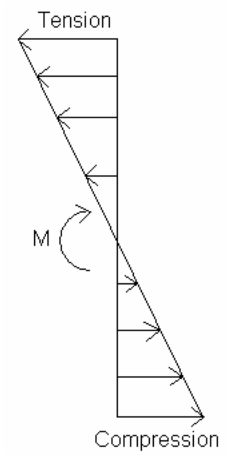
$\tau_{critical}$ = 75,000 psi (from Rockcrawler.com)
1.3 ksi << 75 ksi so the design is safe.



$A_1 = 1.5^2 - 1^2 = 1.25$ in^2
$A_2 = 1^2 - 0.75^2 = 0.4375$ in^2

Bending on Cantilever Seat Mount

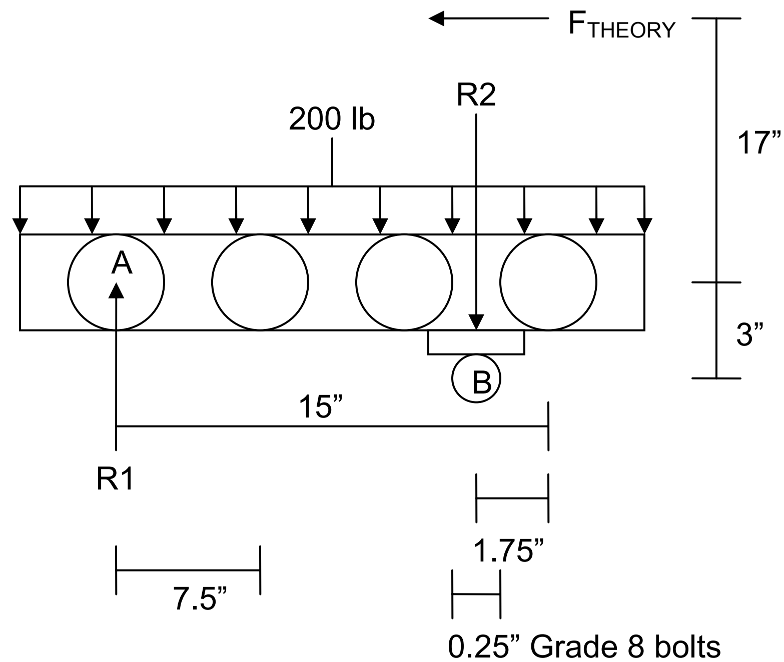




F = (400 lb/18 in)*(7 in) = 155.6 lb
M = FD = (155.6 lb)(3.5 in) = 544.4 in*lb

τ_{max}(1") = M = 544.6 lb*in << $T_{critical}$; on the order ksi

Seat Wheels



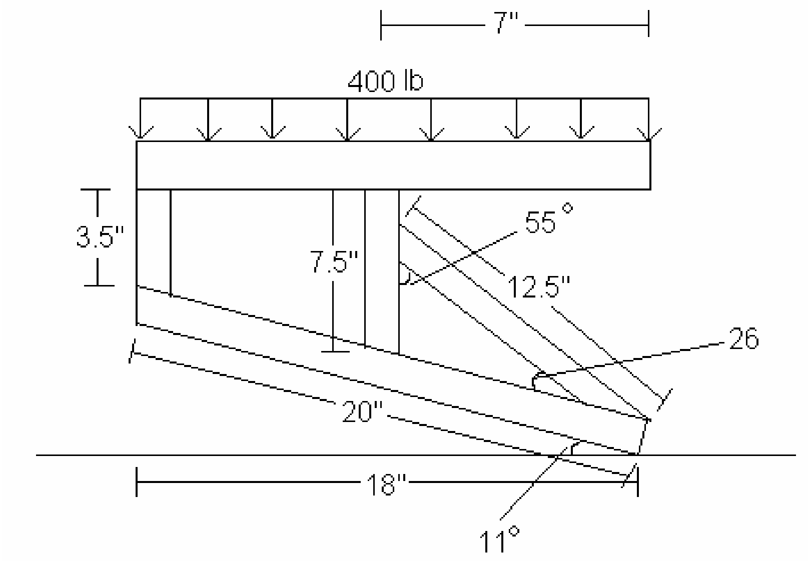
Shear on upper wheels normally:
$\tau_{critical}$ = 91 ksi (Rockcrawler.com)
$\tau_{simple} = (V/4)/A = (200\ lb/4)/(\Pi*(1/8)^2) = 1.02$ ksi << 91 ksi; safe

Shear on lower wheels for R_{Theory}:
$\tau_{critical} = 91\ ksi = V_{critical}/A = V_{critical}/(\Pi(1/8)^2)$ $\quad V_{critical} = 4467$ lb

For M about A:
$M_A = -F_{Theory}(17”) + R_2(13.125”) = 0$
$R_2(13.125”) = F_{Theory}(17”)$
For $R_2 = V_{critical}$:
F_{Theory} = 3449 lbs, so a user would need to exert this force at B for failure to occur. This is highly unlikely to happen due to the large force requirement.

For M about B:
$M_B = R_1(13.125”) – F_{Theory}(20”) = 0$
$R_1(13.125”) = F_{Theory}(20”)$
For $R_1 = V_{critical}$:
F_{Theory} = 2931 lbs, so a user would need to exert this force at A for failure to occur, which is unlikely again due to the large force requirement.

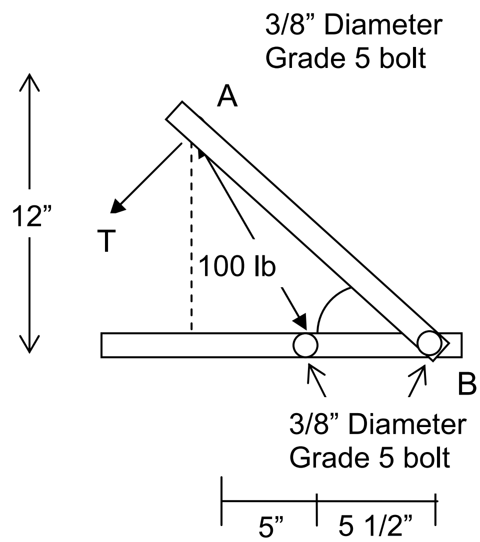
Seat Frame



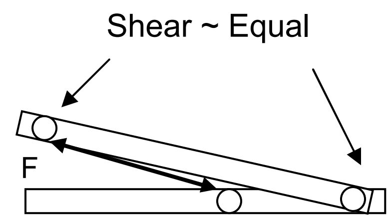
Shear across vertical pillar bases:
A at 0° = 1.25 in^2
A at 11° = 1.25/(cos 11°) = 1.27 in^2 weakest point is at 11°
A at 26° = 1.25/(cos 26°) = 1.39 in^2
$\tau = V/A = (400\ lb)/(1.27\ in^2) = 315\ psi << \tau_{critical}$; on the order of ksi

Buckling of vertical pillars:
This is not an issue because of the short columns, high moment of inertia, high elastic modulus, and low load. The buckling moments and shear will be far less than critical values.

Seat Assist



Shear on rod when down and tension when up



F = 100 lb + Spring Force

As $\theta \rightarrow 0$

F = 100 lb + (55.5 lb/in) * (0.5 in)

F = 127.8 lbs

Thus, $F \ll V_{crit}$

.

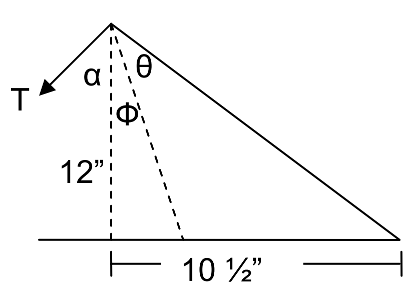
τ_{crit} = 75 ksi = V_{crit} / A

= $V_{crit} / \pi * (3/16")^2$

V_{crit} = 8283 lbs

V_A = 100 lbs
V_B = 100 lbs

} Constant force with respect to piston. Both V_A and V_B much less than V_{crit}



Θ = 41.2°

Φ = 22.6°

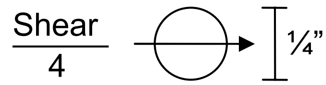
α = 48.2°

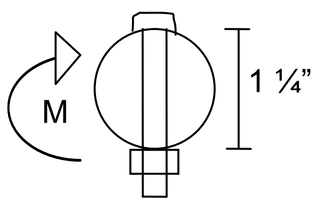
100*cos(22.6°) = T*cos(48.2°)

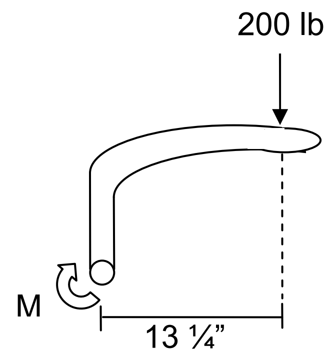
T = 138.5 lbs

EKG Handles

Across 4 bolt cross-sections







τ_{Crit} = 75 ksi

M = 200 lb * 13 ¼" = 2650 lb·in

M = V * 1 ¼"
V = 2120 lbs / 4 = 530 lbs

τ = V/A = 530 lbs/ π * $(1/8")^2$
= 10.8 ksi

10.8 ksi < 75 ksi → Safe