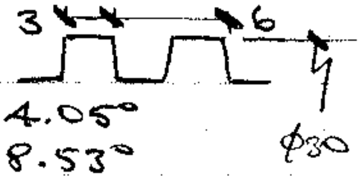
1 $\bar{d} = 30 - 3 = 27$ mm



$\lambda = \arctan L/\pi \bar{d} = \arctan \frac{6}{27\pi} = 4.05°$

$\phi = \arctan \mu \quad = \arctan 0.15 = 8.53°$

a) from (2a) $T = W(\bar{r}\tan(\phi+\lambda) + \mu_b \bar{r}_b)$

$= 100(13.5\tan(8.53+4.05) + 0.1\times 20)$

$= \underline{501}$ Nm

b) speed of screw, $n = 1$ Hz i.e. 1 rev/s

input power $P_i = \omega T$ where $\omega = 2\pi n$

$= 2\pi \times 1 \times 501 = \underline{3.15}$ kW

output power $P_o = v W$ where $v = Ln$

$= 0.006\left(\frac{m}{rev}\right)\times 1\left(\frac{rev}{s}\right)\times 100(kN)$

$= 0.6$ kW

efficiency $\eta = P_o/P_i = 0.6/3.15 = \underline{19}\%$

c) from (2b) with $\mu_b = 0$

$T = W\bar{r}\tan(\phi - \lambda)$

$= 100\times 13.5\tan(8.53-4.05) = \underline{106}$ Nm

This is positive, i.e. consistent with the "unscrewing" sense assumed in deriving (2b) i.e. screw is self-locking.

d) New $\mu = 0.075$ ∴ new $\phi = \arctan 0.075 = 4.29°$

as c) $T = 100\times 13.5\tan(4.29 - 4.05) = 5.7$ Nm

which is still positive. That is self-locking still prevails, but only just! This small torque will be sensitive to vibration and hence screw's self-lock is unreliable

3 Consider all the bolts in parallel, so total initial force is $F_i = 10 \times 5 = 50$ kN.

From (3a) with

$k_e = 1/(1/k_b + 1/k_j) = \frac{k_b k_j}{(k_b + k_j)}$

it follows that

$F_b = F_i + P\, k_e/k_j \quad \& \quad F_j = F_i - P\, k_e/k_b$

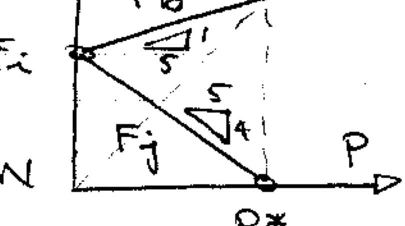
$= F_i + P\, k_b/(k_b + k_j) \quad = F_i - P\, k_j/(k_b + k_j)$

→ $= F_i + \frac{1}{5}P$ here → $= F_i - 4/5\, P$.

since $k_b/k_j = 1/4$.

F_b & F_j plot as shown.

If $F_i = 50$ kN, $P = 20$ kN then



$F_b = 50 + 4 = 54$ kN (i.e. 5.4 kN/bolt)

$F_j = 50 - 16 = 34$ kN

$P^* = \frac{5}{4}F_i$ (i.e. when $F_j = 0$) $= \underline{62.5 \text{ kN}}$