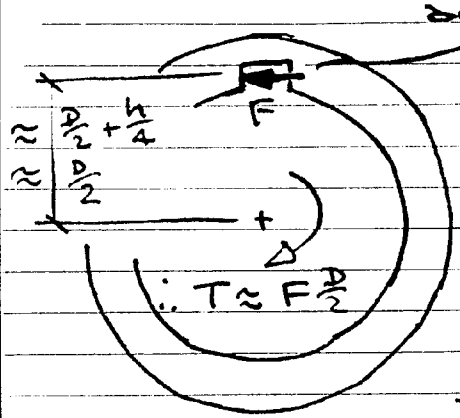
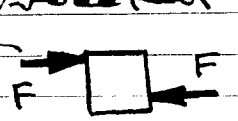
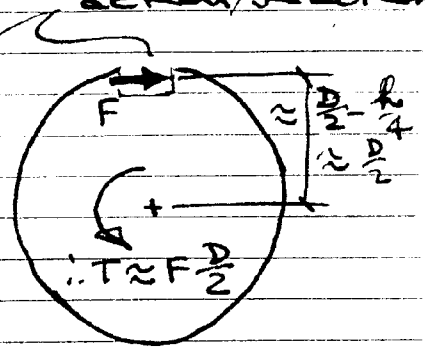
13 First find loads on key by considering FBD's of components.





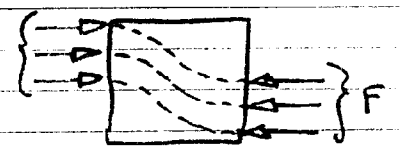
From either boss or shaft F.B.:

$F = 2T/D$ — ②



To a first approx, the key is loaded by the equal-and-opposite forces F. Rotational equil^m requires other effects, but neglect those here.

Examine force/stress transfer within key via hydraulic analogy.



Possible failure modes are:-

"BEARING" (OR "CRUSHING") — σ_c

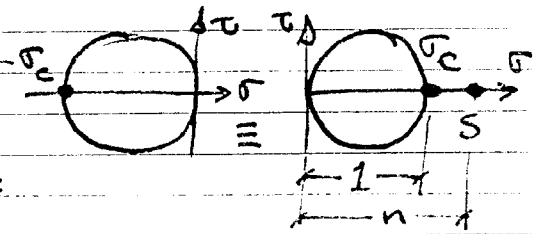
Due to compressive pressure/stress at surface of contact with other components.

$\sigma_c = F/\text{area} = \frac{2T}{D} / \frac{1}{2} hL = 4T/DhL$

By max. shear stress failure theory

$\sigma_e = \hat{\sigma} - \check{\sigma} = 0 - (-\sigma_c) = \sigma_c$

& $\leq S$ for safety



So, substituting for σ_c:

① $DhL \geq 4T/S$

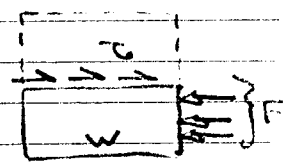
[Always check dimensions of algebraic results:

LHS here = m.m.m ≡ m³
RHS " = Nm/(N/m²) ≡ m³ } OK].

SHEAR Direct shear τ — see FB of ½ :

Assume τ is uniform

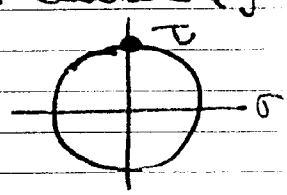
$\tau = F/\text{area} = \frac{2T}{D} / WL = \frac{2T}{DWL}$



[Due to complementary shear, τ will in fact vary as in bending i.e. o⌒o, being necessarily zero at outside]

By max. shear stress theory:

$\sigma_e = \hat{\sigma} - \check{\sigma} = \tau - (-\tau) = 2\tau \leq S$



or, substituting for τ:

② $DWL \geq 4T/S$

[Note key torsion, & $\tau = Tr/J$ is NOT appropriate. Torque is NOT transmitted along key]