introduction into design engineering final report

Q1:

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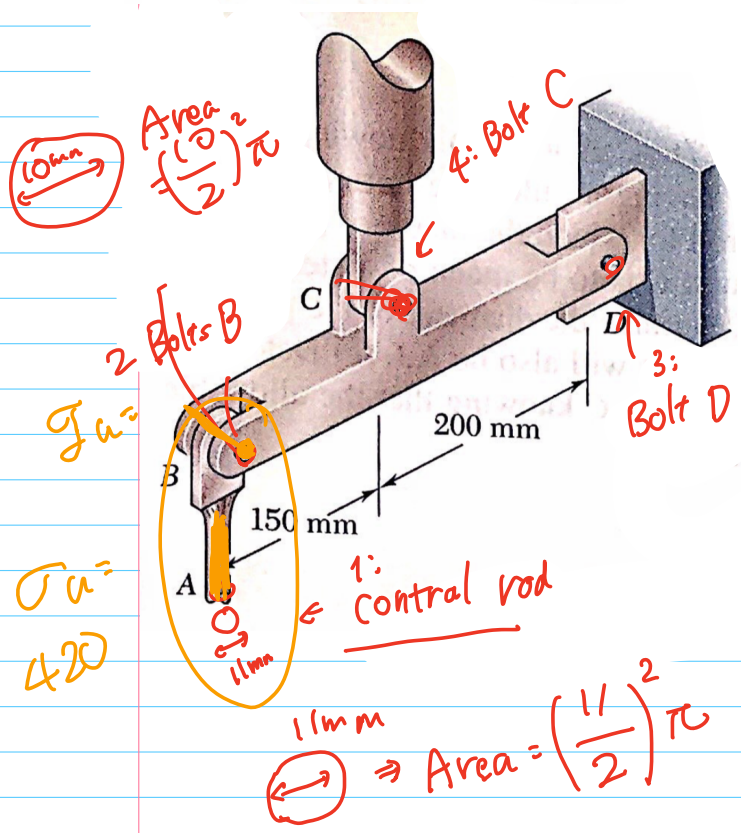
The rigid beam BCD is attached by bolts to a control rod at B, to a hydraulic cylinder at C, and to a fixed support at D. The diameters of the bolts used are: $d_B = d_D = 10$ mm, $d_c = 12$ mm. Each bolt acts in double shear and is made from a steel for which the ultimate shearing stress is $\tau_U = 280$ MPa. The control rod AB has a diameter $d_A = 11$ mm and is made of a steel for which the ultimate tensile stress is $\sigma_U = 420$ MPa. If the minimum factor of safety is to be 3.0 for the entire unit, determine the largest upward force which may be applied by the hydraulic cylinder at C.



10mm ⟷ Area $= \left(\frac{10}{2}\right)^2 \pi$

4: Bolt C

2 Bolts B

3: Bolt D

K

$\tau_u =$

$\sigma_u =$ 420

1: control rod

11mm ⟷ $\Rightarrow$ Area $= \left(\frac{11}{2}\right)^2 \pi$

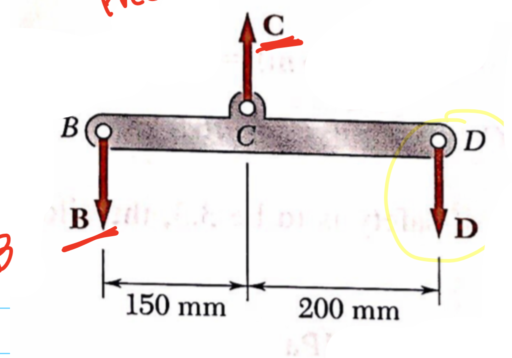
Hints:

The factor of Safety with respect to failure must be 3.0 or more in each of three bolts and in the control rod.

These four independent criteria will be considered separately.

Free body diagram

rod + Bolts B



Hints:

$\circlearrowleft M_B$:

relationship between C and B: C =

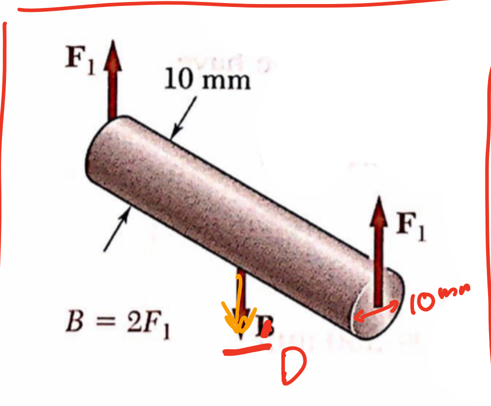
C and D: C = ..D

C = __ D

1: control rod : F.S = 3.0

$\sigma_{all} = \frac{\sigma_u}{F.S} = \frac{420}{3.0} = \sigma_{all}$

$\tau_u = 280\,MPa$



(1) $\sigma_{all} = \frac{F}{A} = \frac{B}{A}$

B = ...

rod: C = __ . B

(1) C = __ kN

(2) $\tau_{all} = \frac{\tau_u}{F.S}$

$\tau_{all} = \frac{F}{2A}$

pin B: $\tau_{all} = \frac{B}{2A}$

B = __

(2) C = __ . B

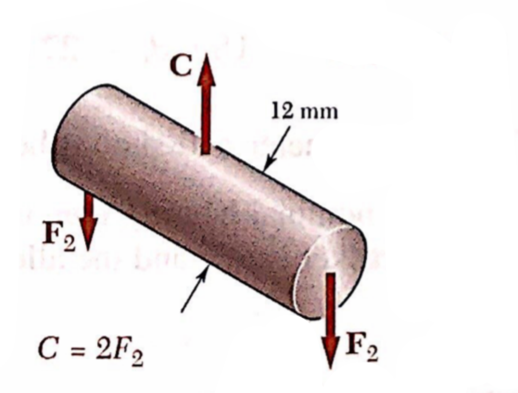
C = __ kN.

$\tau_{all} = \frac{D}{2A}$

D: $\tau_{all} \cdot 2A$

C = ... D

(3) C = ... kN



$\tau_{all} = \frac{\tau_u}{F.S}$

D =

(4) C = ... D

C = kN

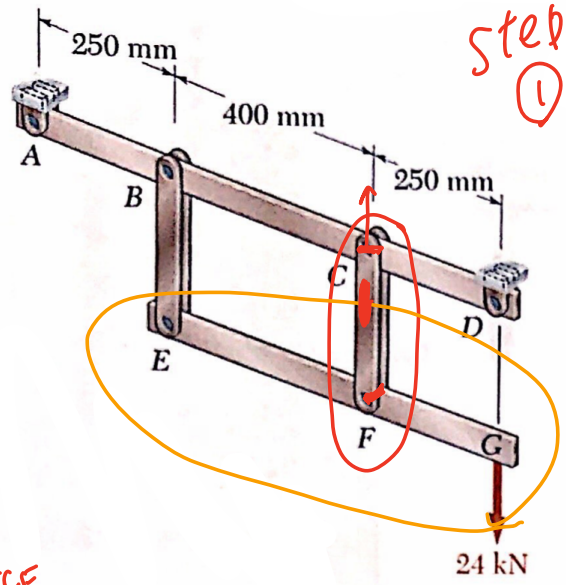
$\tau_{all} = \frac{\tau_u}{F.S}$

$\tau_{all} = \frac{C}{2A}$ C = kN

C = ... kN (4)

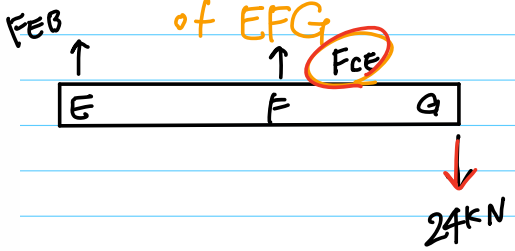
Q2:

Each of the two vertical links *CF* connecting the two horizontal members *AD* and *EG* has a uniform rectangular cross section 10 mm thick and 40 mm wide, and is made of a steel with an ultimate strength in tension of 400 MPa. The pins at *C* and *F* each have a 20-mm diameter and are made of a steel with an ultimate strength in shear of 150 MPa. Determine the overall factor of safety for the links *CF* and the pins connecting them to the horizontal members.



step ①

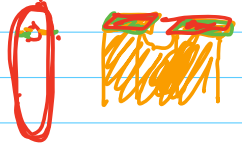
Hints: Free body diagram of EFG



$\sum M_E =$

F_{CF}

step 2: F_{CF}

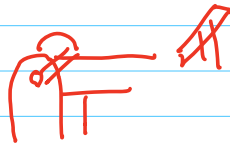


Tension in link CF

Area

$\sigma_u = \frac{F_u}{A} \leftarrow F_u \rightarrow$ ①

step 3: Pin



double shear

Area

$\tau_u = \frac{F_u}{2A}$ $F_u \rightarrow$ ②