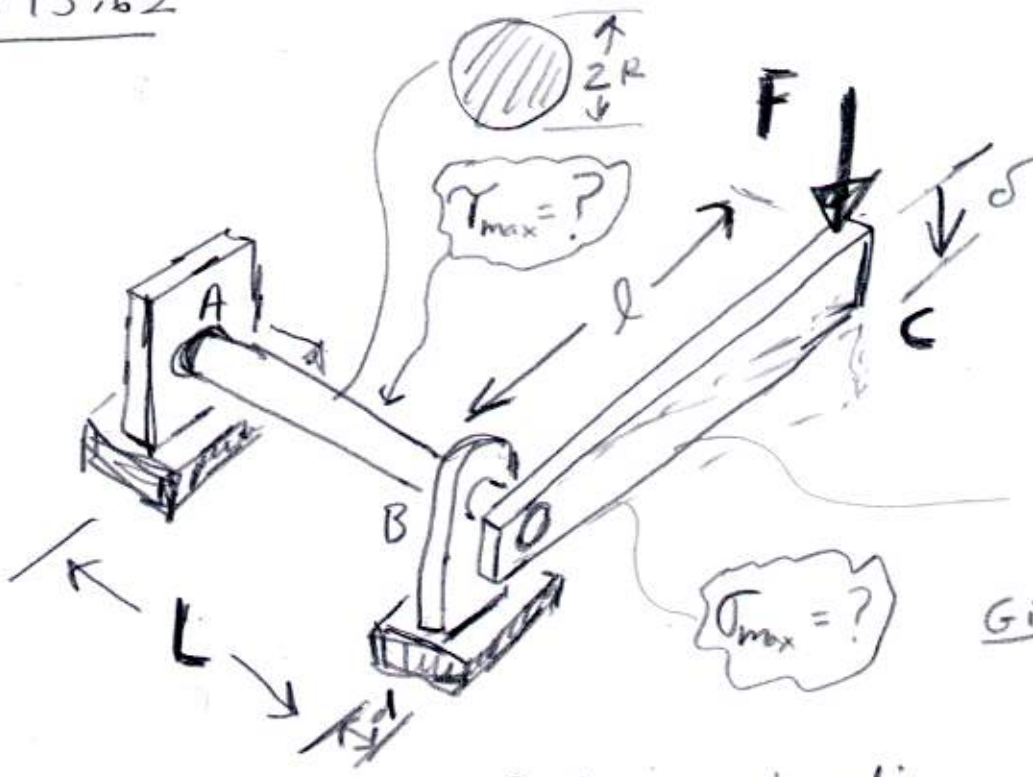
BJ 15.62



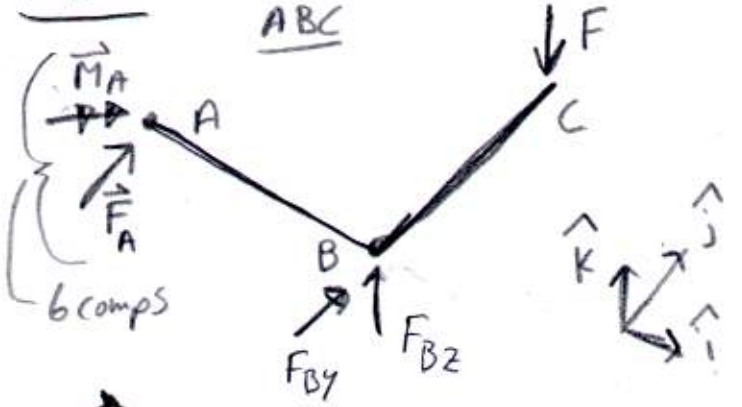
F = 80 lbf

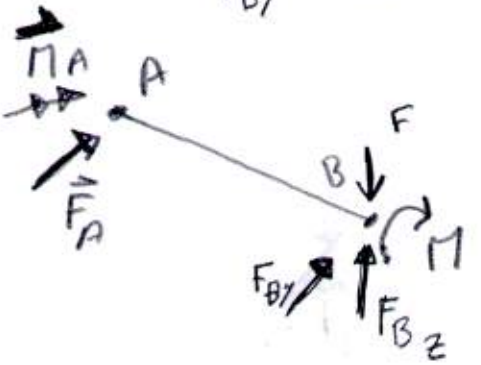
Given:
- $l = 20''$
- $L = 10''$
- $b = 3/8''$
- $h = 1''$
- $R = 7/16''$
- $E = 29 \cdot 10^6$ PSI
- $G = 11.2 \cdot 10^6$ PSI

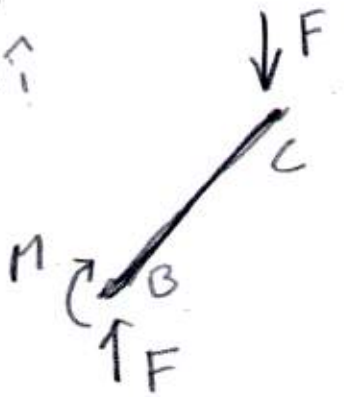
Shaft torsion & beam bending. Neglected.

FBDs

ABC







Note

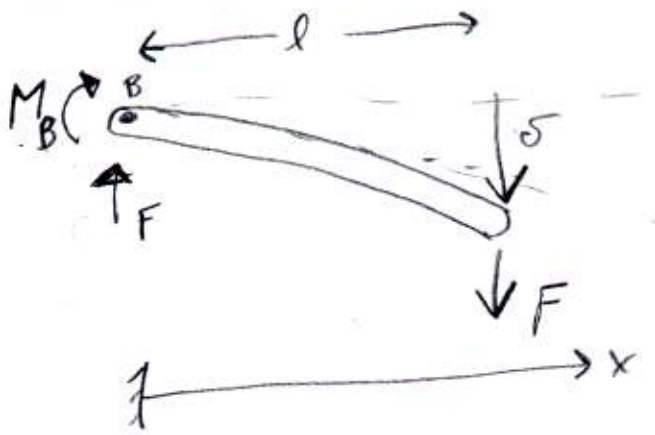
Wall at A prevents all translations & rotations ⇒ 6 comps

Support at B prevents motion in y & z dir ⇒ 2 comps

Bending prob.

$\curvearrowleft \Sigma M = 0$

$M_B = -F\ell$



ϕ = rotation from torsion proble

$V = F$

$M = Fx + M_B = Fx - F\ell$

$u' = \frac{1}{EI}\left[Fx^2/2 - F\ell x + u'(0) \right]$ ($u'(0) = -\phi$)

$u = \frac{1}{EI}\left[Fx^3/6 - F\ell x^2/2 - \phi x \right]$

$u(L) = \frac{F\ell^3}{3EI} - \phi\ell$ ①

Torsion Problem

F_{Bx} & F_{Bz} don't cause twist. So only worry about M_B.

$T = \frac{JG\phi}{L} \Rightarrow \phi = \frac{M_B L}{JG} = \frac{F\ell L}{JG}$ ②

T ↑ M_B

① + ② $\Rightarrow$ $u(L) = \frac{F\ell^3}{3EI} + \frac{F\ell L^2}{JG} = \boxed{F\ell^2\left[\frac{\ell}{3EI} + \frac{L}{JG}\right]}$

cont'd

```
%BJ15.62d
% consistent units of lbf and inches
%Given
F = 80;
l = 20;
L = 10;
b = 3/8;
h = 1;
R = 7/16;
E = 29e6;
G = 11.2e6;

%Calculate
I=b*h^3/12;
J = pi*R^4/2;
JG = J*G;
EI = E*I;
Mmax = F*l;
T    = Mmax;  % torsion torque
c1 = R;   %  mac radius for torsion
c2 = h/2;  %  max y for bending stress

 delta = F*l^2*(l/(3*EI) + L/(J*G))

 %max tension
 sigma_max = Mmax*c2/I
 tau_max   = T*c1/J


%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%Output
```

$I = bh^3/12$

$J = \pi R^4/2$


```
delta =

    0.7319
```
in

```
sigma_max =

       25600
```
lbf/in^2 ← $\sigma = Mc/I$

```
tau_max =

   1.2164e+04
```
lbf/in^2 ← $\tau = Tc/J$

12,100 PSI