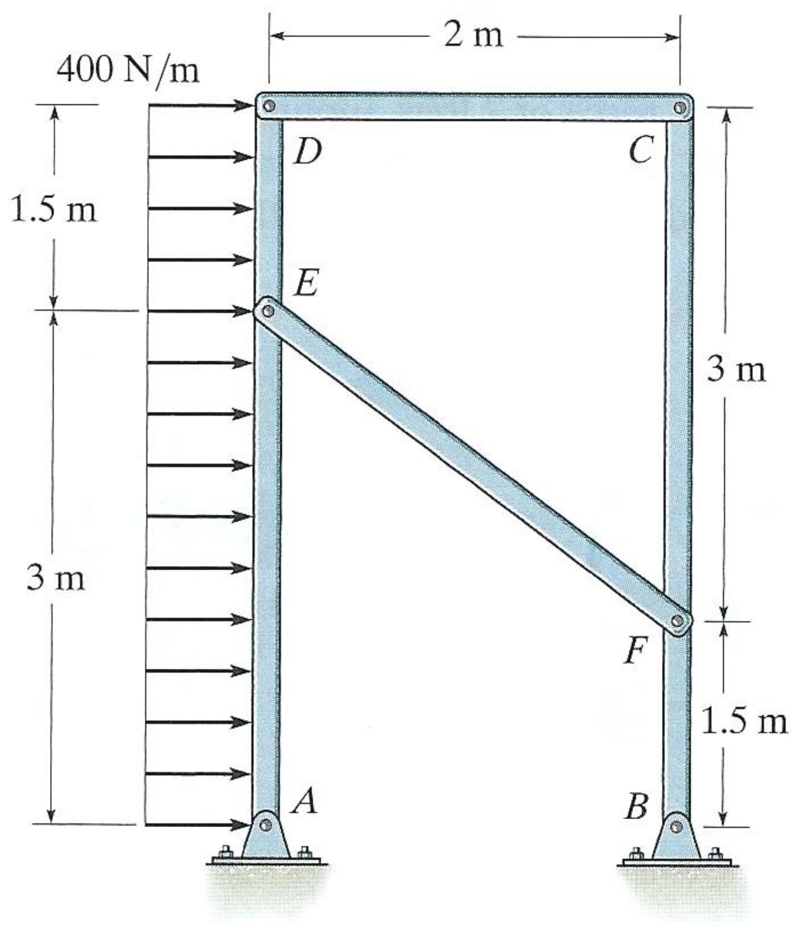
Wright State University
Department of Mechanical and Materials Engineering Fall 2016

ME 2120: STATICS

FINAL EXAM

OPEN BOOK, CLOSED NOTES, SHOW ALL WORK FOR PARTIAL CREDIT

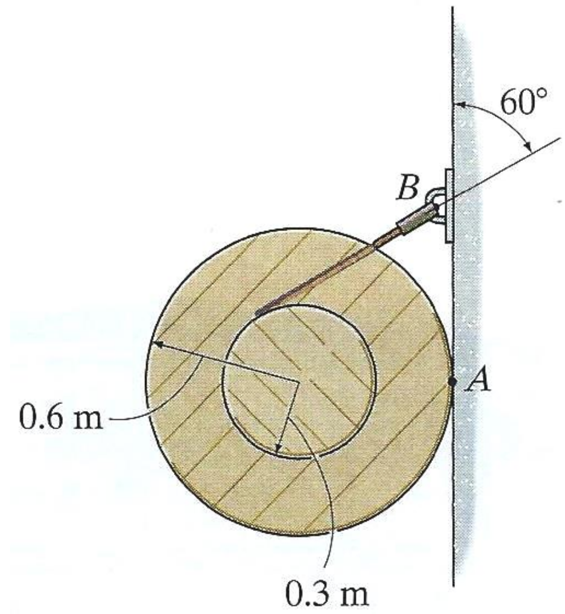
Problem 1: (10 points) Determine the horizontal and vertical components of force which the pins at *A* and *B* exert on the frame, and the forces in all two-force members. State whether the two-force members are in tension or compression.



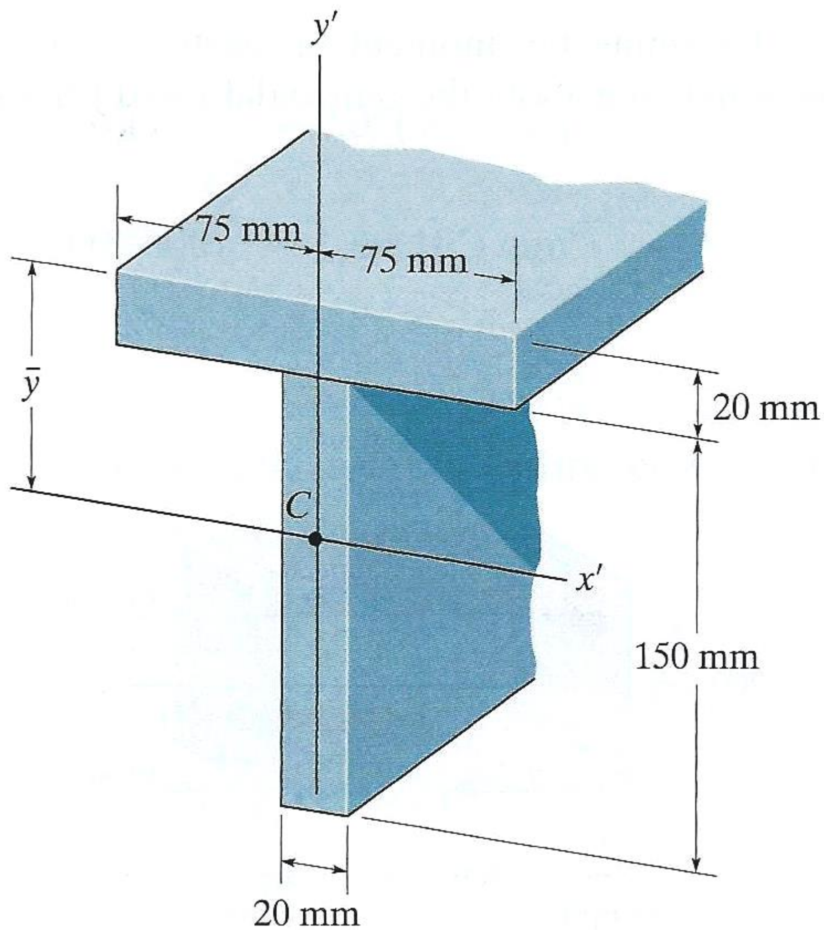
Problem 2: (5 points) For the frame in Problem 1, determine the axial force, the shear force and the bending moment in member *BFC* at the point that is mid-way between points *B* and *F*.

Problems 3 and 4 are on the back of this sheet.

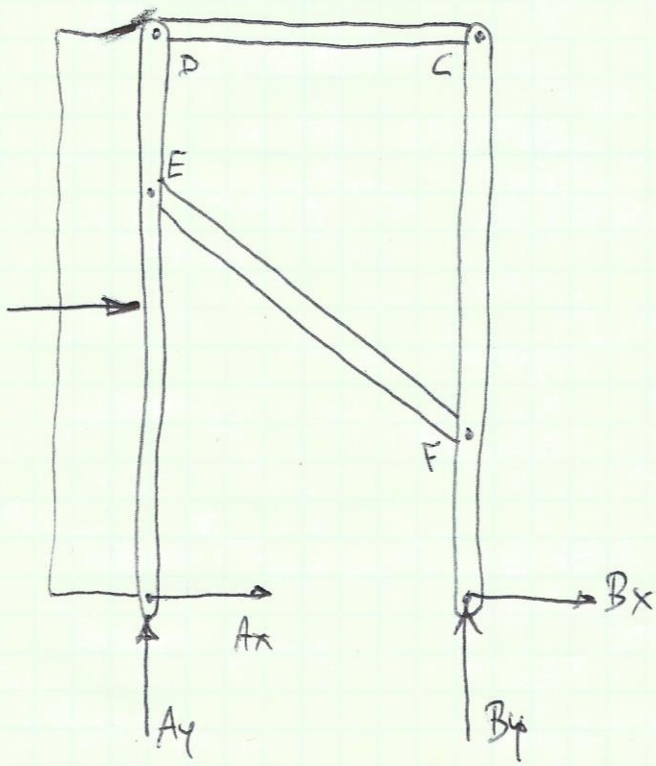
Problem 3: (6 points) Determine the minimum coefficient of static friction between the uniform 50-kg spool and the wall so that the spool does not slip.



Problem 4: (9 points) Determine $\bar{y}$, which locates the centroidal axis x' for the cross-sectional area of the T-bar, and then find the moment of inertia of area about the x' axis.



PROB. 1



$\vec{F} = (400 \frac{N}{m})(4.5^m)\hat{i}$

$\vec{F} = (1800)\hat{i}\ ^N$

$\Sigma F_x = 0$:

$A_x + B_x + 1800 = 0$

$\Sigma F_y = 0$:

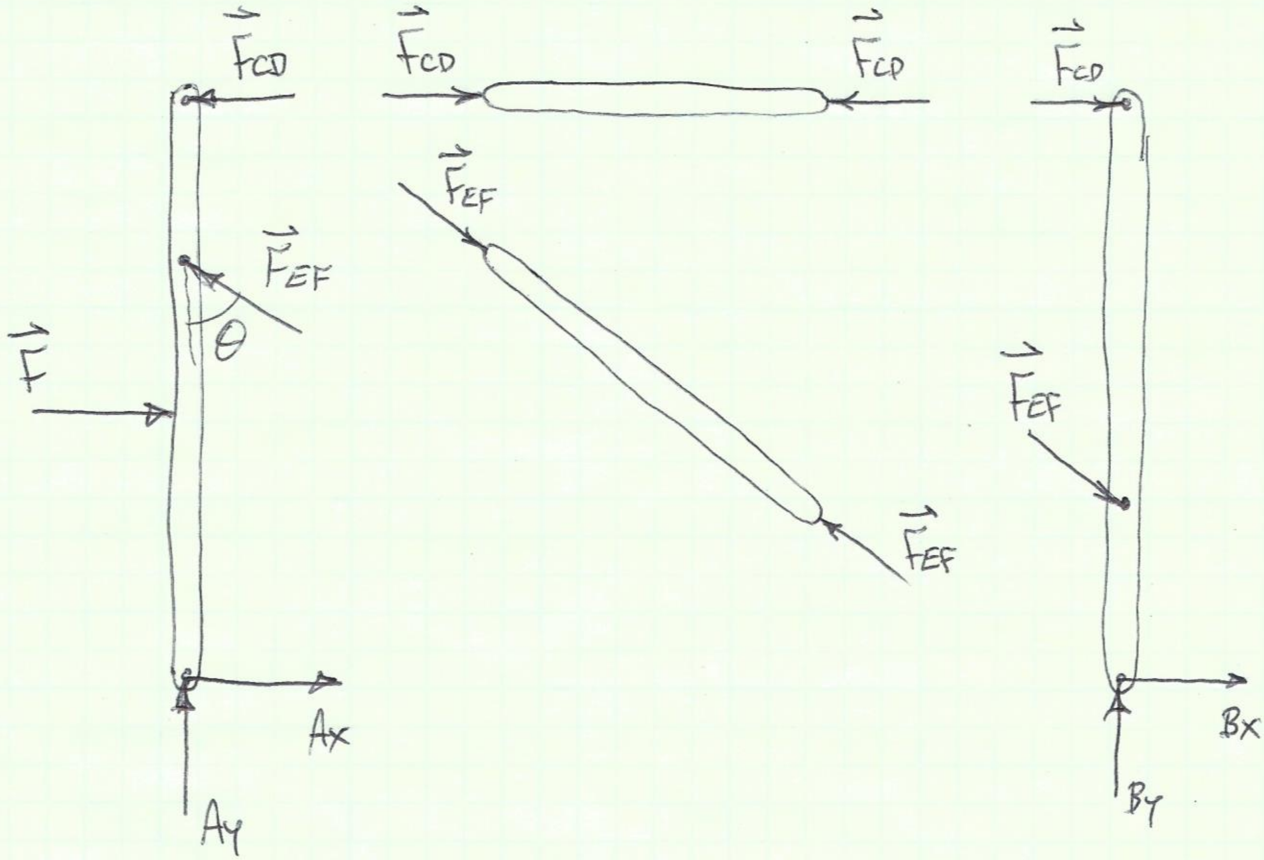
$A_y + B_y = 0$

$\Sigma M_A = 0$ +↺:

$-(2.25^m)(1800^N) + (2^m) B_y = 0$

$\boxed{B_y = 2025^N}$

$\boxed{A_y = -B_y = -2025^N}$



MEMBER AED:

$$\theta = \tan^{-1}\left(\frac{2}{1.5}\right) = 53.1^\circ$$

$$\vec{F}_{EF} = (-\sin 53.1^\circ \cdot F_{EF})\hat{i} + (\cos 53.1^\circ \cdot F_{EF})\hat{j} \ \text{N}$$

$$\vec{F}_{EF} = (-0.8\, F_{EF})\hat{i} + (0.6\, F_{EF})\hat{j} \ \text{N}$$

$\Sigma F_x = 0$:

$$A_x + 1800 - 0.8\, F_{EF} - F_{CD} = 0$$

$\Sigma F_y = 0$:

$$A_y + 0.6\, F_{EF} = 0$$

$$\boxed{F_{EF}} = -\left(\frac{-2025}{0.6}\right) = \boxed{3375^N \text{ (C)}}$$

$$\vec{F}_{EF} = [-0.8(3375)]\hat{i} + [(0.6)(3375)]\hat{j} \ ^N$$

$$\vec{F}_{EF} = (-2700)\hat{i} + (2025)\hat{j} \ ^N$$

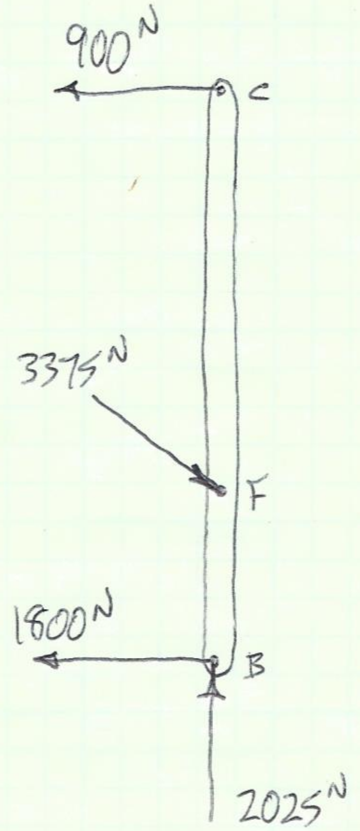
$\Sigma M_A = 0$ (+↺):

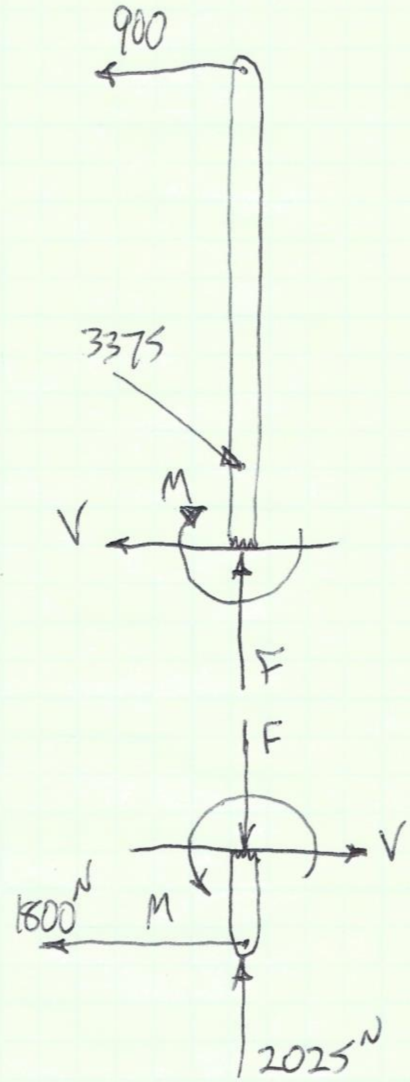
$$-(2.25^m)(1800^N) + (3^m)(2700^N) + (4.5^m)\cdot F_{CD} = 0$$

$$\boxed{F_{CD} = -900^N \text{ (T)}}$$

$$\boxed{A_x} = -1800 + 0.8(3375) + (-900) = \boxed{0}$$

$$\boxed{B_x = -1800^N}$$





$\Sigma F_x = 0$:

$V - 1800 = 0$, $\boxed{V = 1800^N}$

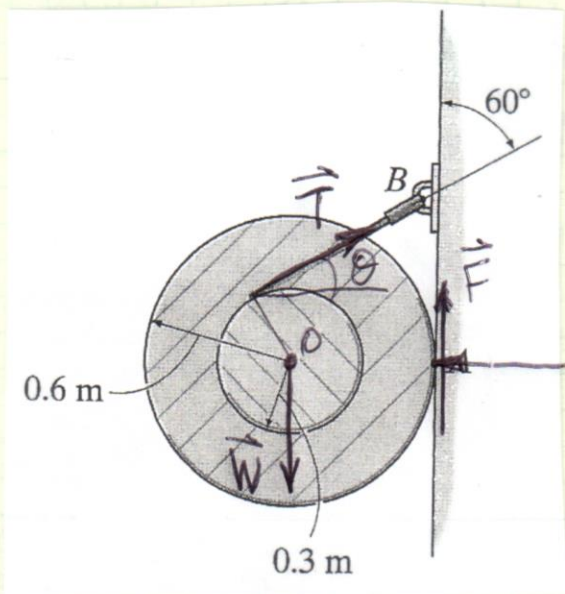
$\Sigma F_y = 0$:

$2025 - F = 0$, $\boxed{F = 2025^N}$

$\Sigma M_{CUT} = 0$ (+↺):

$M - (0.75^m)(1800^N) = 0$

$\boxed{M = 1350^{N \cdot m}}$



IMPENDING MOTION:

$F = \mu_s N$

$\mu_s = \dfrac{F}{N}$

$\theta = 30°$

$\vec{W} = (-mg)\hat{j} = [-(50^{kg})(9.81 \frac{m}{s^2})]\hat{j}\ N = (-490.5)\hat{j}\ N$

$\vec{T} = (\cos 30° \cdot T)\hat{i} + (\sin 30° \cdot T)\hat{j}\ N$

$\vec{T} = (0.866T)\hat{i} + (0.5T)\hat{j}\ N$

$\Sigma F_x = 0$:

$-N + 0.866T = 0$, $\boxed{N = 0.866T}$ ①

$\Sigma F_y = 0$:

$F - W + 0.5T = 0$ ②

$\Sigma M_O = 0 \circlearrowleft^{+}$:

$(0.6^m)F - (0.3^m)T = 0$, $\boxed{F = \frac{1}{2}T}$ ③

$T = 490$

③ INTO ②:

$(\frac{1}{2}T) - W + 0.5T = 0$, $\boxed{W = T}$ ④

(4) INTO (1):

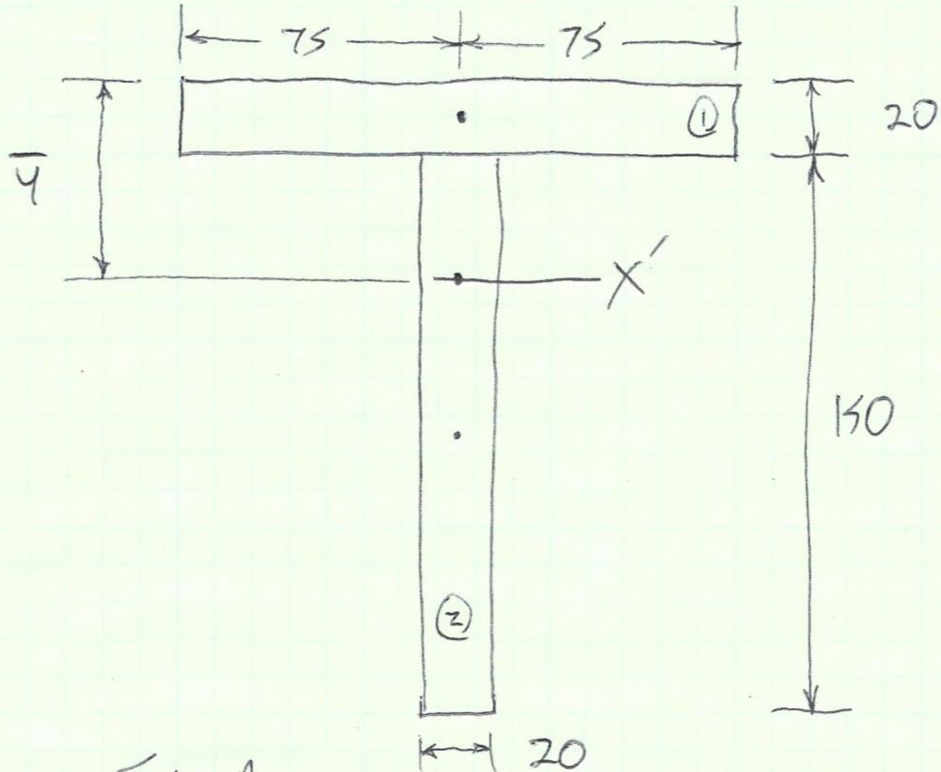
$$\boxed{N} = 0.866\,W = 0.866\,(490.5) = \boxed{424.8\,N}$$

(4) INTO (3):

$$\boxed{F} = \tfrac{1}{2}W = \tfrac{1}{2}(490.5) = \boxed{245.3\,N}$$

$$\boxed{\mu_s} = \frac{F}{N} = \left(\frac{245.3}{424.8}\right) = \boxed{0.5773}$$

PROB. 4



$$\bar{y} = \frac{\sum y_i A_i}{\sum A_i}$$

AREA 1:

$$A_1 = (150^{mm})(20^{mm}) = 3000\ mm^2$$

$$y_1 = \tfrac{1}{2}(20^{mm}) = 10^{mm}$$

$$y_1 A_1 = (10^{mm})(3000^{mm^2}) = 3 \times 10^4\ mm^3$$

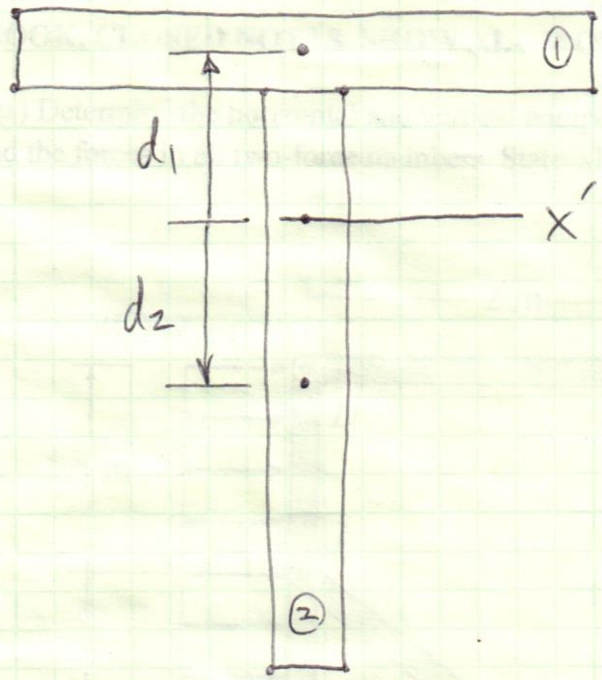
AREA 2:

$$A_2 = (150^{mm})(20^{mm}) = 3000\ mm^2$$

$$y_2 = 20 + \tfrac{1}{2}(150) = 95^{mm}$$

$$y_2 A_2 = (95^{mm})(3000\ mm^2) = 2.85 \times 10^5\ mm^3$$

$$\boxed{\bar{Y}} = \frac{\Sigma(Y_i A_i)}{\Sigma A_i} = \frac{(3\times10^4) + (2.85\times10^5)\ mm^3}{(3000) + (3000)\ mm^2} = \boxed{52.5\ mm}$$



$$I_{x'} = I_{x1} + I_{x2}$$

$$I_{x1} = \bar{I}_{x1} + Ad_1^2 = \frac{1}{12}bh^3 + bh\cdot d_1^2$$

$$I_{x1} = \frac{1}{12}(150)(20)^3 + (150)(20)(52.5-10)^2 = 5.519\times10^6\ mm^4$$

$$I_{x2} = \bar{I}_{x2} + Ad_2^2 = \frac{1}{12}bh^3 + bh\cdot d_2^2$$

$$I_{x2} = (\tfrac{1}{12})(20)(150)^3 + (150)(20)(20+75-52.5)^2$$

$$I_{x2} = 1.104\times10^7\ mm^4$$

$$\boxed{I_{x'}} = (5.519\times10^6) + (1.104\times10^7) = \boxed{1.656\times10^7\ mm^4}$$