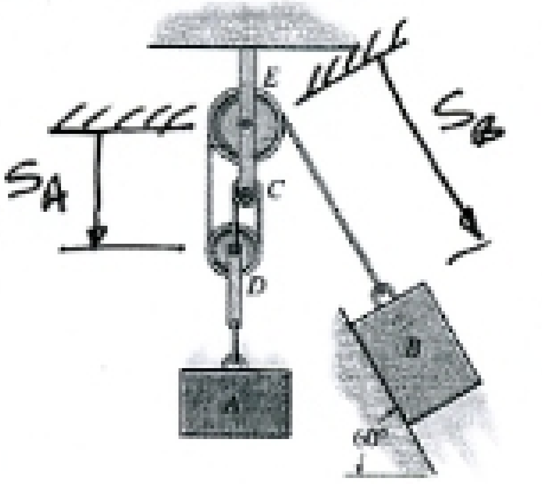
EM 202 **Test #1** **Spring 2006**

Name (print): KEY
Honor Code: I have neither given nor received unauthorized aid on this test
Signature:

1. (30 pts) Block B weighs 100 lb. The ropes and pulleys have negligible weight and the pulleys are frictionless. The static and kinetic coefficients between block B and the inclined surface are 0.3 and 0.2, respectively. Find the **maximum weight block A** can have before it starts to pull block B up the slope. Then add one pound to that weight of block A and find the **accelerations of blocks A and B** and the **tension in the cable**.



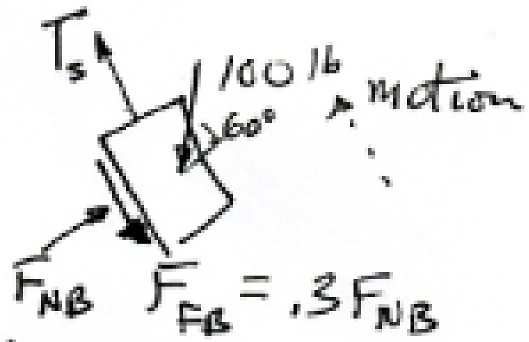
$L = 3s_A + s_B + \text{consts}$

$\dot{L} = 3v_A + v_B = 0$

$\ddot{L} = 3a_A + a_B = 0 \quad \therefore\ a_B = -3a_A$

Statics: Find A_{max} ie. friction on B = limiting value & B wants to move up: $= \mu_s F_{NB}$

Block B:



$\nearrow \Sigma F_N = 0 = F_{NB} - 100\cos 60$

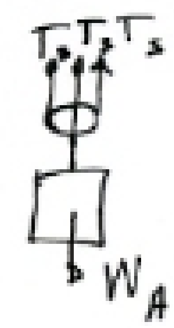
$F_{NB} = 50\ \text{lb}$

$\nwarrow \Sigma F_T = 0 = T_s - 100\sin 60 - .3(50)$

$\boxed{T_s = 101.6\ \text{lb}}$

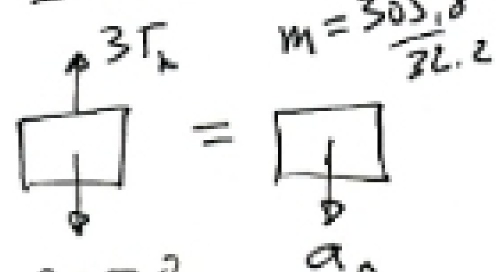
Block A: $\uparrow \Sigma F_y = 0 = 3T - W_A$

$\boxed{W_A = 304.8\ \text{lb}}$



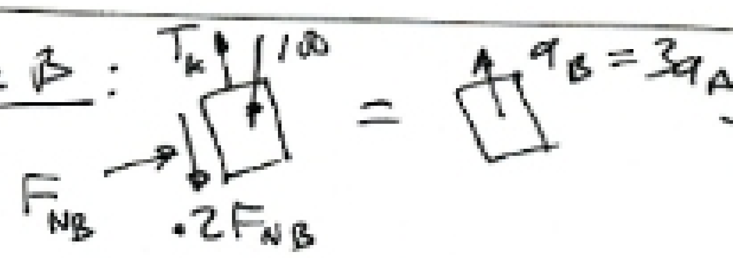
Dynamics:

Block A:



$+\downarrow \Sigma F_y = 305.8 - 3T_k = \frac{305.8}{32.2} a_A$

Block B:

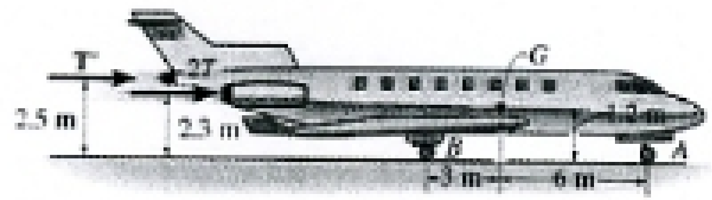


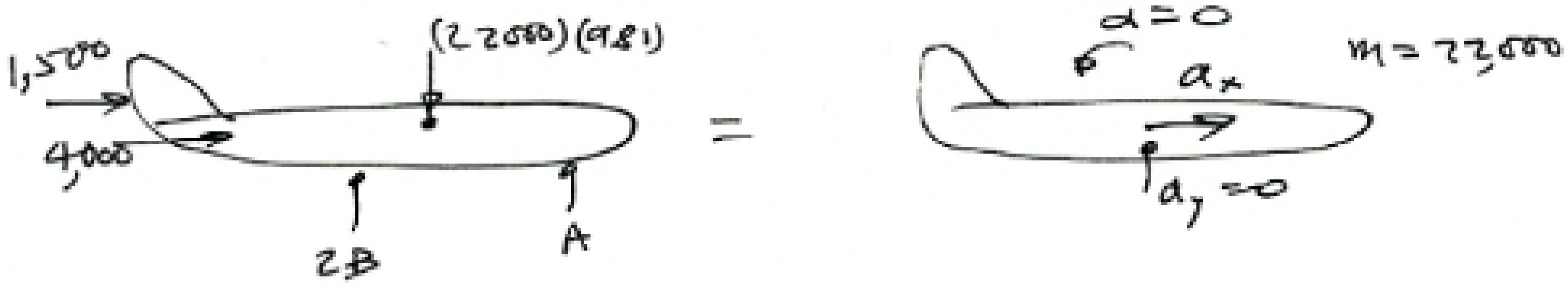
$F_{NB} = 50\ \text{lb}$ as before

$\nwarrow \Sigma F_T = T_k - 100\sin 60 - .2(50) = \frac{100}{32.2} a_B$

Solve:
$$\boxed{\begin{aligned} a_A &= 0.4271\ \text{ft/sec}^2 \downarrow \\ a_B &= 1.281\ \text{ft/sec}^2 \nwarrow \\ T_k &= 100.6\ \text{lb} \end{aligned}}$$

2. (25 pts) The jet aircraft has a mass of 22 Mg (i.e. 22,000 kg) and a center of gravity as shown at G. The instant after the pilot releases the brakes for takeoff, the engine thrusts are 2T = 4 kN and T' = 1.5 kN. The velocity is essentially zero as the jet just starts to move, so there is no appreciable lift or drag on the wings and other parts of the jet. Find the **acceleration** at this instant and the **reactions on the nose wheel and each of the two main wing wheels** at this instant. The runway is level and rolling friction is negligible. The mass of the wheels is negligible. Rotation of the jet due to tire or landing gear deformations is negligible.





$$\rightarrow \Sigma F_x = (1{,}500 + 4{,}000)\,N = 22000\ kg\ a_x$$

$$\boxed{a_x = 0.25\ m/sec^2}$$

$$\curvearrowleft \Sigma M_G = 0 = -1500(1.3) - 4000(1.1) - 2B(3) + A(6)$$

$$6A - 6B = 6350$$

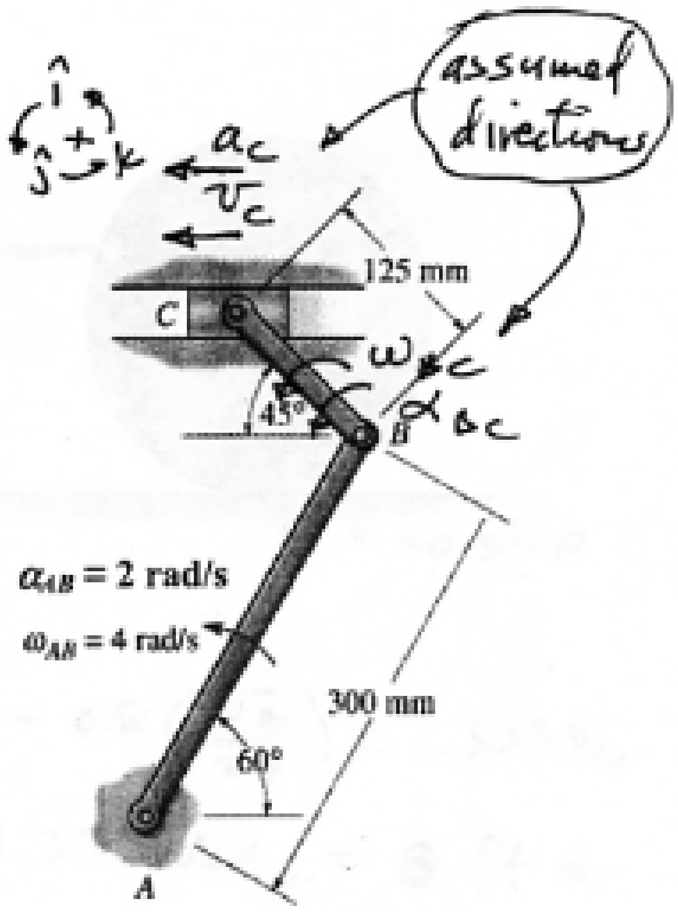
$$\uparrow \Sigma F_y = 0 = 2B + A - 215820$$

$$A + 2B = 215820$$

Solve:

$$\boxed{\begin{array}{l} A = 72{,}646\ N \uparrow \\ B = 71{,}587\ N \uparrow \text{ each wing wheel} \end{array}}$$

2. (35 pts) The bar AB is being moved with the angular speed and acceleration shown. Pin A is stationary. The motion is in a vertical plane. Block C can only move horizontally.
   a. First, find the acceleration of the block C in the position shown.
   b. Then find the force transmitted to block C through the 2-force member BC. The slider block C has a mass of 10 kg. The mass of the two bars is negligible. The kinetic coefficient of friction between block C and its horizontal guide is 0.20. All pins are frictionless.



Bar AB:

$\bar{v}_B = \bar{v}_A + \bar{\omega}_{AB} \times \bar{r}_{B/A}$

$= 0 + (4\hat{k}) \times (.15\hat{i} + .2598\hat{j})$

$\bar{v}_B = (-1.039\hat{i} + 0.60\hat{j})$ m/sec

$\bar{a}_B = \bar{a}_A + \bar{\alpha} \times \bar{r}_{B/A} - \omega^2 \bar{r}_{B/A}$

$= 0 + (2\hat{k}) \times (.15\hat{i} + .2598\hat{j}) - (4)^2(.15\hat{i} + .2598\hat{j})$

$\bar{a}_B = (-2.920\hat{i} - 3.857\hat{j})$ m/sec^2 (6)

Bar BC: $\bar{v}_C = \bar{v}_B + \bar{\omega}_{BC} \times \bar{r}_{C/B} = -v_c\hat{i}$ from diag.

$= (-1.039\hat{i} + 0.60\hat{j}) + (\omega_{BC}\hat{k}) \times (-.08839\hat{i} + .08839\hat{j})$

$-v_c\hat{i} = (-1.039 - 0.08839\,\omega_{BC})\hat{i} + (0.60 - 0.08839\,\omega_{BC})\hat{j}$

$\hat{j}$: $0 = 0.60 - .08839\,\omega_{BC}$ $\therefore$ $\omega_{BC} = 6.788 \frac{rad}{sec}$ (6)

$\hat{i}$: $v_c = 1.639$ m/sec $\leftarrow$

$\bar{a}_c = \bar{a}_B + \bar{\alpha}_{BC} \times \bar{r}_{C/B} - \omega_{CB}^2 \bar{r}_{C/B} = -a_c\hat{i}$ from diag.

$= (-2.920\hat{i} - 3.857\hat{j}) + (\alpha_{BC}\hat{k}) \times (-.08839\hat{i} + 0.08839\hat{j}) - (6.788)^2(-0.08839\hat{i} + 0.08839\hat{j})$

$-a_c\hat{i} = (1.153 - 0.08839\,\alpha_{BC})\hat{i} + (-7.930 - 0.08839\,\alpha_{BC})\hat{j}$ (6)

$\hat{j}$: $0 = -7.930 - .08839\,\alpha_{BC}$ $\therefore$ $\alpha_{BC} = -89.71 = 89.71 \frac{rad}{sec^2}$

$\hat{i}$: $-a_c = 1.153 - .08839(-89.71)$

(6) $\therefore$ $\boxed{a_c = 9.08 \rightarrow \text{m/sec}^2}$