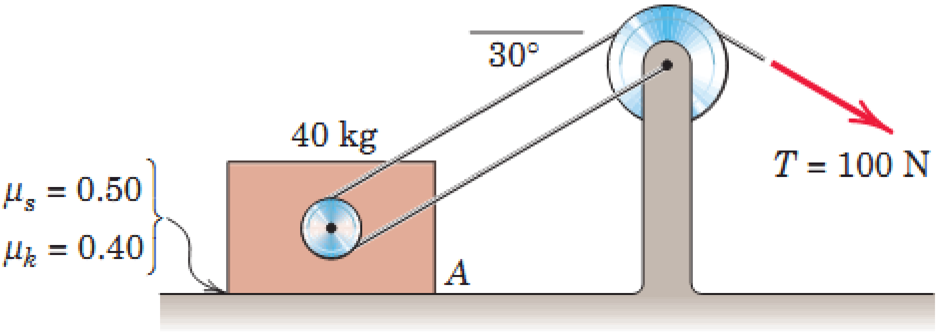
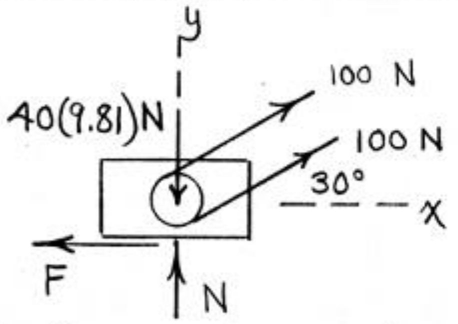
ME 206 – DYNAMICS – SPRING 2017

STUDY PROBLEMS-5 (PARTICLE KINETICS, SECTION A)

PROBLEM 3/37

Compute the acceleration of block *A* for the instant depicted. Neglect the masses of the pulleys.





$\begin{cases} \mu_s = 0.5 \\ \mu_k = 0.4 \end{cases}$

$\Sigma F_y = 0: \quad N + 200 \sin 30° - 40(9.81) = 0$

$N = 292 \text{ N}$

Assume static equilibrium :

$\Sigma F_x = 0: \quad -F + 200 \cos 30° = 0, \quad F = 173.2 \text{ N}$

$F_{max} = \mu_s N = 0.5(292) = 146.2 \text{ N} < F$

Assumption wrong, motion exists →.

$F = \mu_k N = 0.4(292) = 117.0 \text{ N}$

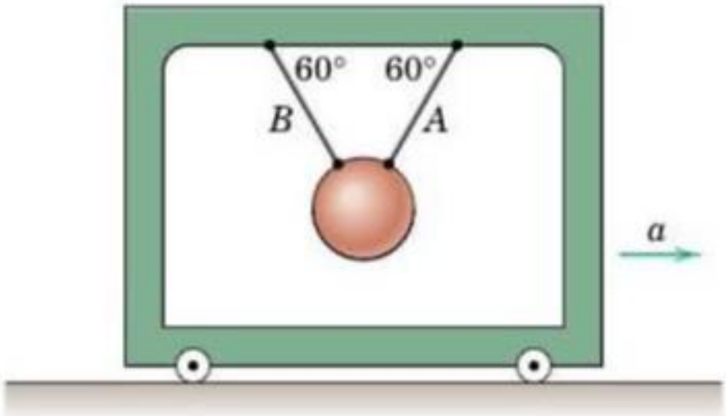
$\Sigma F_x = m a_x : \quad -117 + 200 \cos 30° = 40\, a_x$

$a_x = a = 1.406 \text{ m/s}^2$

PROBLEM 3/17 (6th Ed.)

The steel ball is suspended from the accelerating frame by the two cords A and B. Determine the acceleration a of the frame which will cause the tension in A to be twice that in B.

Ans. $a = \dfrac{g}{3\sqrt{3}}$



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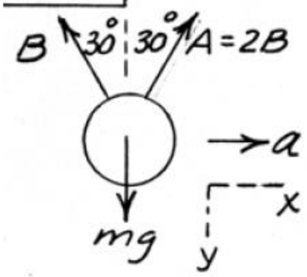


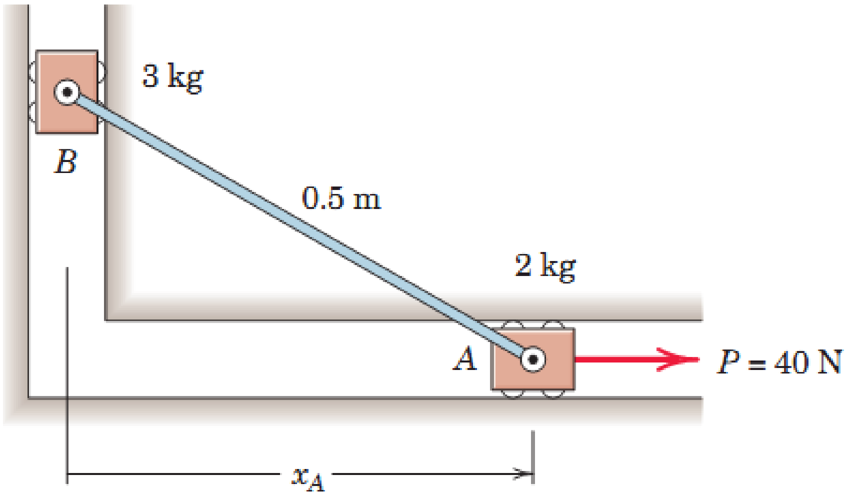
$\Sigma F_x = ma_x$; $2B\sin 30° - B\sin 30° = ma$

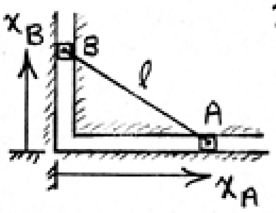
$\Sigma F_y = 0$; $2B\cos 30° + B\cos 30° - mg = 0$

Eliminate B & set $\underline{a = g/3\sqrt{3}}$

PROBLEM 3/32

The sliders A and B are connected by a light rigid bar of length $l = 0.5$ m and move with negligible friction in the slots, both of which lie in a horizontal plane. For the position where $x_A = 0.4$ m, the velocity of A is $v_A = 0.9$ m/s to the right. Determine the acceleration of each slider and the force in the bar at this instant.





$$x_A^2 + x_B^2 = l^2$$

$$2 x_A \dot{x}_A + 2 x_B \dot{x}_B = 0$$

$$x_A \ddot{x}_A + \dot{x}_A^2 + x_B \ddot{x}_B + \dot{x}_B^2 = 0$$

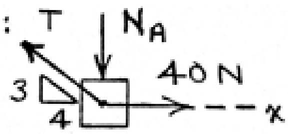
$$\text{So } \dot{x}_B = -\frac{x_A \dot{x}_A}{x_B} = \frac{-(0.4)(0.9)}{0.3} = -1.2 \text{ m/s}$$

$$\ddot{x}_B = \frac{-\dot{x}_B^2 - \dot{x}_A^2 - x_A \ddot{x}_A}{x_B} = \frac{-1.2^2 - 0.9^2 - 0.4\ddot{x}_A}{0.3}$$

$$= -7.5 - \frac{4}{3}\ddot{x}_A \quad \text{or} \quad a_B = -7.5 - \frac{4}{3}a_A \quad (1)$$

Draw FBDs of sliders A and B.
The rigid bar is a two-force member because it is massless. So the forces applied by the bar on the sliders A and B are along line AB and are equal to each other (denoted as T).

A:



$$\Sigma F_x = ma_x: \; 40 - \frac{4}{5}T = 2a_A \quad (2)$$

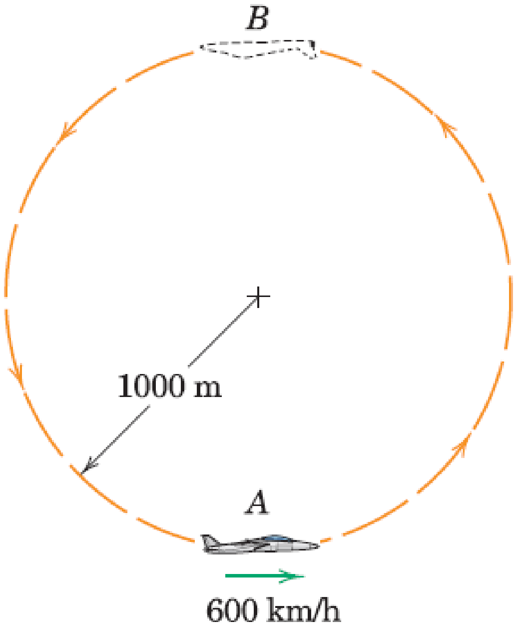
B:

$$\Sigma F_x = ma_x: \; -\frac{3}{5}T = 3a_B \quad (3)$$

Solution of Eqs. (1)-(3):
$$\begin{cases} a_A = 1.364 \text{ m/s}^2 \\ a_B = -9.32 \text{ m/s}^2 \\ T = 46.6 \text{ N} \end{cases}$$

PROBLEM 3/65

A pilot flies an airplane at a constant speed of 600 km/h in the vertical circle of radius 1000 m. Calculate the force exerted by the seat on the 90-kg pilot at point *A* and at point *B*.



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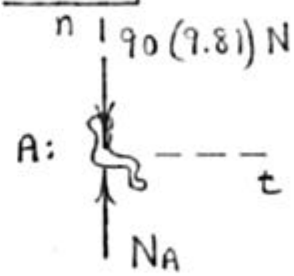
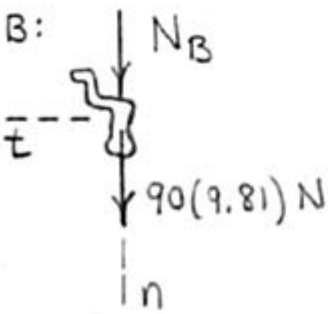


$\Sigma F_n = ma_n$:

$N_A - 90(9.81) = 90 \dfrac{(600/3.6)^2}{1000}$

$\underline{N_A = 3380 \text{ N}}$



$\Sigma F_n = ma_n$:

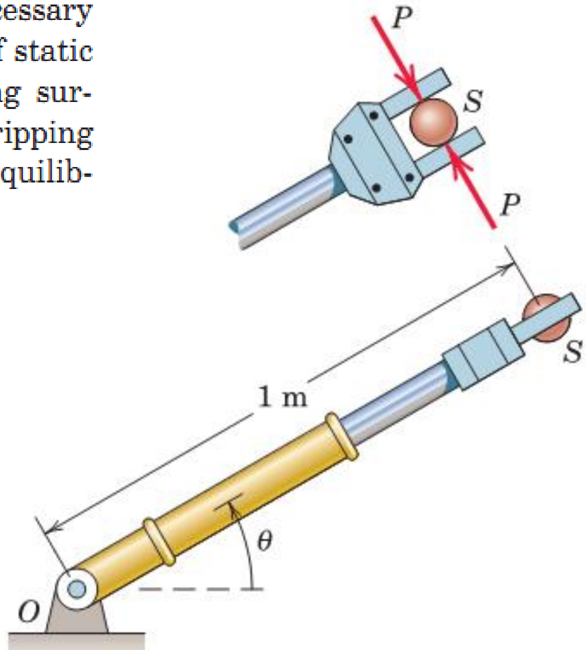
$N_B + 90(9.81) = 90 \dfrac{(600/3.6)^2}{1000}$

$\underline{N_B = 1617 \text{ N}}$

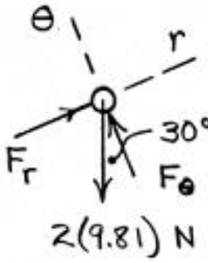
(Note static normal $mg = 90(9.81) = 883$ N)

PROBLEM 3/72

A 2-kg sphere S is being moved in a vertical plane by a robotic arm. When the angle θ is 30°, the angular velocity of the arm about a horizontal axis through O is 50 deg/s clockwise and its angular acceleration is 200 deg/s^2 counterclockwise. In addition, the hydraulic element is being shortened at the constant rate of 500 mm/s. Determine the necessary minimum gripping force P if the coefficient of static friction between the sphere and the gripping surfaces is 0.50. Compare P with the minimum gripping force P_s required to hold the sphere in static equilibrium in the 30° position.



F_r and F_θ are the r- and θ-components of the total friction force F.



$\Sigma F_r = ma_r = m(\ddot{r} - r\dot{\theta}^2)$:

$F_r - 19.62 \sin 30° = 2[0 - 1(-0.873)^2]$

$F_r = 8.29$ N

$\Sigma F_\theta = ma_\theta = m(r\ddot{\theta} + 2\dot{r}\dot{\theta})$

$F_\theta - 19.62 \cos 30° = 2[(1)(3.49) + 2(-0.5)(-0.873)]$

$F_\theta = 25.7$ N

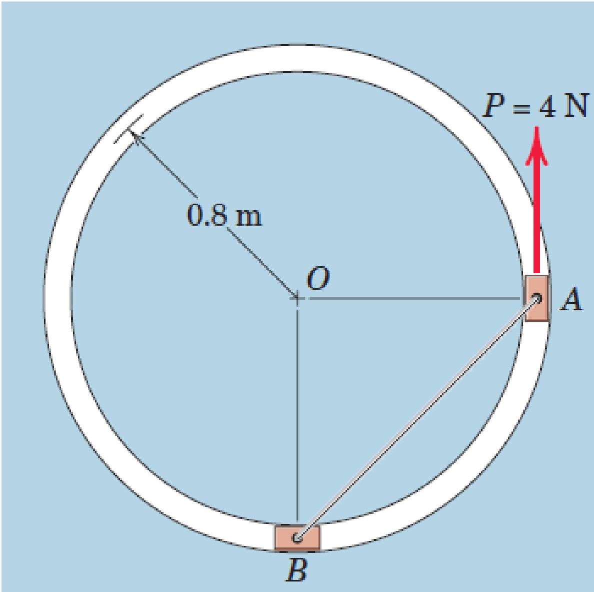
$F = \sqrt{F_r^2 + F_\theta^2} = 27.0$ N

$P = \dfrac{F/2}{\mu_s} = \dfrac{27.0/2}{0.5} = \underline{27.0 \text{ N}}$

(Static gripping force $= \underline{19.62 \text{ N}}$)

PROBLEM 3/87

The two 0.2-kg sliders A and B move without friction in the horizontal-plane circular slot. Determine the acceleration of each slider and the normal reaction force exerted on each when the system starts from rest in the position shown and is acted upon by the 4-N force P. Also find the tension in the inextensible connecting cord AB.



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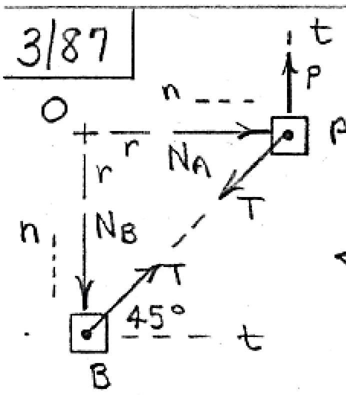

Ⓐ :

$\Sigma F_t = m a_t$:

$P - T\cos 45° = 0.2\, a_t$ (1)

$\Sigma F_n = m a_n$:

$-N_A + T\sin 45° = 0$ (2)

Ⓑ :

$\Sigma F_t = m a_t$: $T\cos 45° = 0.2\, a_t$ (3)

$\Sigma F_n = m a_n$: $-N_B + T\sin 45° = 0$ (4)

(Note: a_t is common to both bodies)

Solution of Eqs. (1)–(4), with $P = 4$ N:

$a_t = 10\ \text{m/s}^2$, $N_A = 2$ N, $N_B = 2$ N

$T = 2.83$ N