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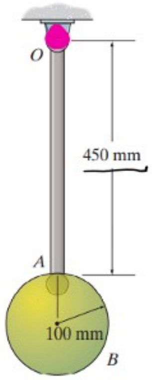
•17–21. Determine the mass moment of inertia of the pendulum about an axis perpendicular to the page and passing through point O. The slender rod has a mass of 10 kg and the sphere has a mass of 15 kg.

5.27



$$I_O = I_{OA} + I_{OB} = 0.675 + 4.59 = 5.27\ \mathrm{Kgm}^2$$

$$I_{OA} = \frac{1}{12} m l^2 + md^2$$
$$= \frac{1}{12}(10)(.45)^2 + (10)(.225)^2 = 0.675\ \mathrm{Kgm}^2$$

$$I_{OB} = \frac{2}{5} mr^2 + md^2$$
$$= \frac{2}{5}(15)(0.1)^2 + (15)(0.55)^2 = 4.59\ \mathrm{Kgm}^2$$

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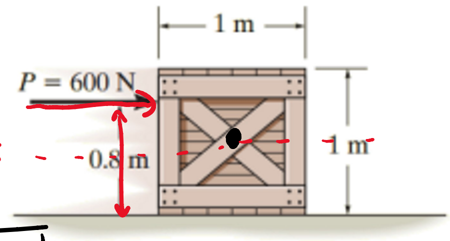
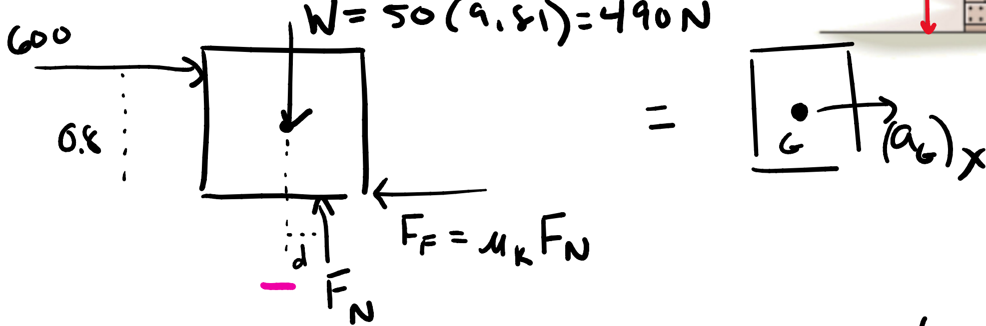
$m = 50\,kg$

Example 1: A uniform crate rests on a horizontal surface for which the coefficient of friction is $\mu_k = 0.2$. Determine the crate's acceleration if a force P = 600N is applied to the crate as shown.





$$\xrightarrow{+} \Sigma F_x = m(a_G)_x$$

$$600 - F_F = 50(a_G)_x$$

$$600 - \mu_k F_N = 50(a_G)_x$$

$$600 - (0.2)(490) = 50(a_G)_x$$

$$(a_G)_x = 10.04\,m/s^2 \longrightarrow$$ only valid if $d < 0.5$

$$\uparrow \Sigma F_y = m(a_G)_y$$

$$F_N - 490 = 0$$

$$F_N = 490\,N$$

$$\circlearrowleft \Sigma M_G = 0$$

$$490d - 600(.3) - (.2)(490)(.5) = 0$$

$$d = 0.467\,m \quad (\text{valid})$$

Planar Equations of Motion

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$\Sigma \bar{F} = m \bar{a}_G$ a_G = acceleration of center of mass

$\Sigma F_x = m(a_G)_x$

$\Sigma F_y = m(a_G)_y$

Translational Equations of Motion

$\Sigma M_G = I_G \alpha$ — Rotational Equation of motion

For translation

$\Sigma M_G = 0$

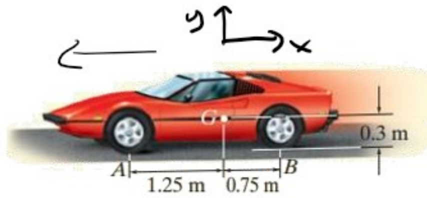
N-T coordinates (Translation)

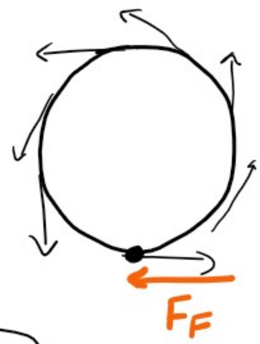
$\Sigma F_N = m(a_G)_N$

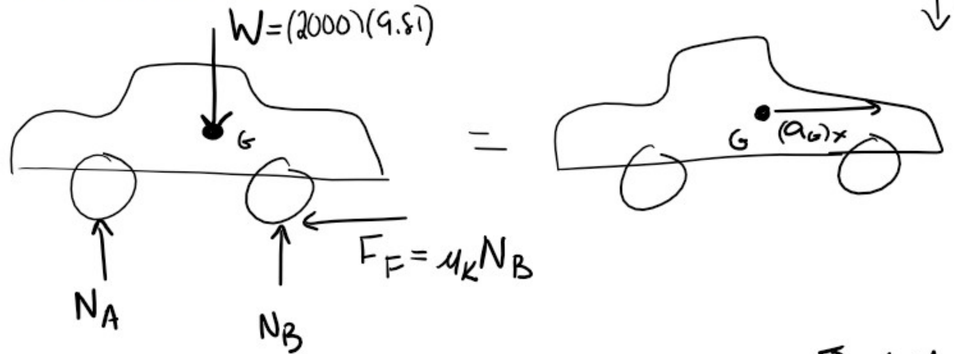
$\Sigma F_T = m(a_G)_T$

$\Sigma M_G = 0$

Example 2: The car shown has a mass of 2 Mg and a center of mass at G. Determine the acceleration if the rear driving wheels are always slipping, whereas the front wheels are free to rotate. Neglect the mass of the wheels. The coefficient of kinetic friction between the wheels and the road is $\mu_k = 0.25$







$\xrightarrow{+} \sum F_x = m(a_G)_x$

$-F_F = 2000(a_G)_x$ (Kg)

$-(0.25)N_B = 2000(a_G)_x$

$-(0.25)(12740) = 2000(a_G)_x$

$(a_G)_x = -1.59\ m/s^2$

$= 1.59\ m/s^2 \leftarrow$

$+\uparrow \sum F_y = m(a_G)_y$

$-W + N_A + N_B = 0$

$-(2000)(9.81) + N_A + N_B = 0$

$0.54N_B + N_B = 19620$

$N_B = 12740\ N$

$\circlearrowleft \sum M_G = 0$

$(-N_A)(1.25) + N_B(0.75) - (0.25)(N_B)(0.3) = 0$

$.75N_B - 0.075N_B = 1.25N_A$

$0.675N_B = 1.25N_A$

$0.54N_B = N_A$

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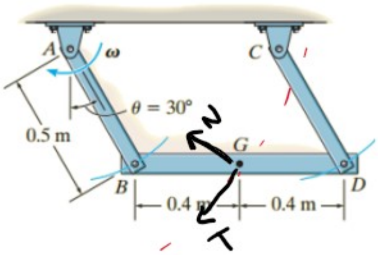
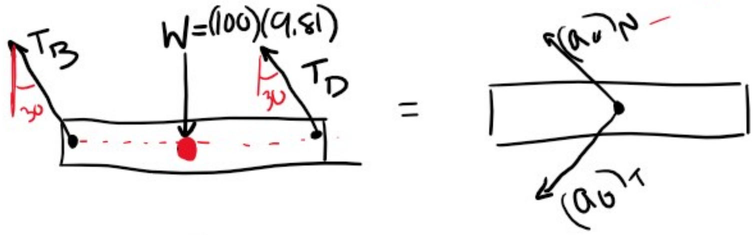
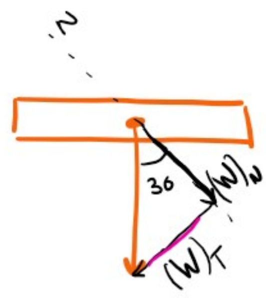
Example 3: The 100 kg beam is supported by two roads having negligible mass. Determine the force in each rod if at the instant theta = 30, ω =6 rad/s







$$\uparrow + \Sigma F_N = m(a_G)_N$$

$$T_B + T_D - (100)(9.81)\cos 30 = 100(a_G)_N$$

$$T_B + T_D - (100)(9.81)\cos 30 = (100)(18)$$

$$T_B + T_B - 981\cos 30 = (100)(18)$$

$$T_B = T_D = 1324.8\,N$$

$$(a_G)_N = \omega^2 r$$

$$= (6^2)(.5) = 18\ m/s^2$$

$$\Sigma F_T = m(a_G)_T$$

$$981 \sin 30 = 100(a_G)_T$$

$$(a_G)_T = 4.9\ m/s^2$$

$$\circlearrowright + \Sigma M_G = 0$$

$$T_B\cancel{\cos 30(0.4)} - T_D\cancel{\cos 30(0.4)} = 0$$

$$T_B = T_D$$

$$a_G = \sqrt{4.9^2 + 18^2}$$