20-R-KIN DK35-44

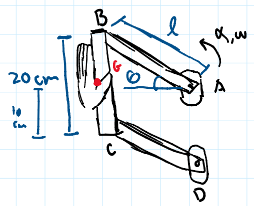
June 8, 2020 11:35 AM

CH17-DK-35 Intermediate Multibody (RBK)

Inspiration: R17-2

Reword

Reword and redo → problem doesn't work



A lonely engineer has made himself a machine to give optimal high-fives. If link AB and CD have length $\ell = 30$ cm and contact the engineer's hand at an angle of $\theta = 25°$, determine the force and moment which the link BC exerts on the hand at H. In the instant shown, link AB has an angular velocity of $\omega = 5$ rad/s and an angular acceleration of $\alpha = 1.5$ rad/s². Assume the hand has a mass of $m = 0.4$ kg and link BC has a mass of $m = 0.5$kg

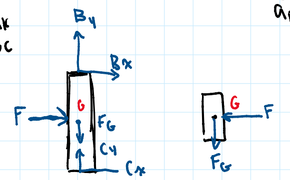
$K_G =$

Assume the mass of other links is negligible

$$\vec{a}_B = \vec{a}_A + \vec{\alpha} \times \vec{r}_{B/A} - \omega^2 \vec{r}_{B/A} \qquad \vec{a}_A = \vec{0} \qquad \hat{k}\ \hat{i}\ \hat{j}$$

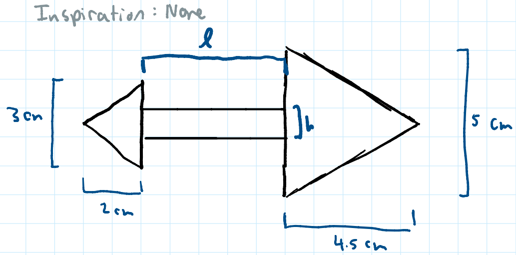
$$\vec{a}_B = 1.5\hat{k} \times (-0.3\cos 25\,\hat{i} + 0.3\sin 25\,\hat{j}) - (5)^2(-0.3\cos 25\,\hat{i} + 0.3\sin 25\,\hat{j})$$
$$= -0.45\cos 25\,\hat{j} - 0.45\sin 25\,\hat{i} + 7.5\cos 25\,\hat{i} - 7.5\sin 25\,\hat{j}$$

Link BC



CH17-DK-36 Beginner Centroids

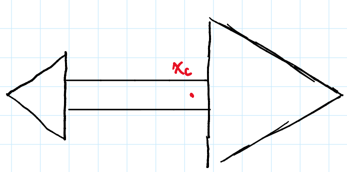
Inspiration: None



Determine the centroid of the object if $\ell = 5$cm and $h = 1$cm

$$A_T = A_1 + A_2 + A_3$$
$$= \tfrac{1}{2}(3\text{cm})(2\text{cm}) + (5\text{cm})(1\text{cm}) + \tfrac{1}{2}(4.5\text{cm})(5\text{cm})$$
$$= 19.25\ \text{cm}^2$$

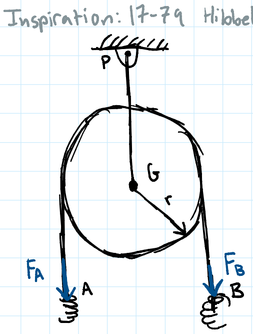
$$x_c = \frac{\sum x_i A_i}{A_T} = \frac{(2 - \frac{1}{2}(2))(3) + (2 + \frac{1}{2}(5))(5) + (2 + 5 + \frac{1}{3}(4.5))(11.25)}{19.25}$$



$$= 6.344155444$$

CH17-DK-37 Intermediate Rotation (RBK)

Inspiration: 17-79 Hibbeler ← Beginner Maybe



Two rowdy kids are having a strength competition. Andy pulls with a force of $F_A = 20$ N and Brian, who has been hitting the gym recently, pulls with a force of $F_B = 45$N. If the pulley can be modelled as a disk of mass $m = 5$kg with a radius $r = 15$cm, determine the acceleration of Andy's hand at A at that instant. Assume the mass of the cord is negligible and no slipping occurs.

and the tension in PG

$$I_G = \tfrac{1}{2}mr^2 = \tfrac{1}{2}(5)(0.15)^2 = 0.05625$$

$$\sum F_x = 0 \qquad \sum F_y = T - F_A - F_B - F_g = 0$$
$$T = F_A + F_B + mg = 20 + 45 + (5)(9.81) = \boxed{114.05}$$

$\Sigma F_x = 0 \qquad \Sigma F_y = T - F_A - F_B - F_g = 0$

$T = F_A + F_B + mg = 20 + 45 + (5)(9.81) = \boxed{114.05}$

$\Sigma M_G = F_A(0.15) - F_B(0.15) = I_G \alpha$

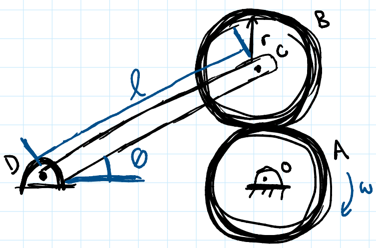
$= 20(0.15) - 45(0.15) = -3.75 = 0.05625\,\alpha \qquad \boxed{\alpha = -66.\overline{66}\ rad/s^2}$

Pinned at G $\rightarrow$ $a = \alpha \times r = -66.66\hat{k} \times (-0.15\hat{i}) = \boxed{10\ \hat{j}\ m/s^2}$

CH17-DK-38 Intermediate (or Advanced) Rotation (RBK)

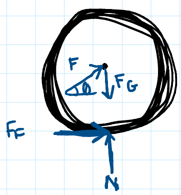
Inspiration: 17-77 Hibbeler

Inspired by my actual 223 Rover concept



An engineering student is working on an experimental drive system that utilizes two wheels to shift between drive and neutral.
Wheel A rotates with a constant angular velocity of $w = 15\ rad/s$ and has a mass of 1.1 kg. Wheel B has a mass of $m = 1.6\ kg$ and is initially at rest when it is put into contact with wheel A.
If the coefficient of kinetic friction between the two wheels is $\mu_k = 0.3$, determine the time required for wheel B to reach the same angular speed as wheel A. Assume the two wheels can be modelled as disks with radius $r = 0.1\ m$ and that the mass of bar CD is negligible. The length of the bar CD is given as $l = 0.8\ m$ and the angle is $\theta = 30°$.

$I_c = \frac{1}{2}mr^2 = \frac{1}{2}(1.6)(0.1)^2 = 0.008$



$\Sigma F_x = ma_{Gx} = 0.3N + F\cos 30 = 0 \qquad 0.3N = -F\cos 30$

$\Sigma F_y = ma_{Gy} = N - F_G + F\sin 30 = 0 \qquad N = (1.6)(9.81) - F\sin 30$

$\Sigma M_c = 0.3N(0.1) = I_c\alpha = 0.008\alpha \qquad 0.03N = 0.008\alpha$

$0.3(1.6)(9.81) - 0.3F\sin 30 = -F\cos 30$

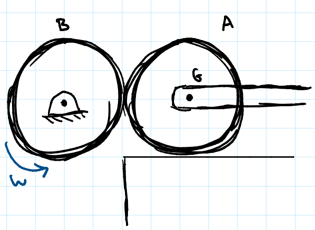
$4.7088 = \frac{3 - 10\sqrt{3}}{20}F \qquad F = -6.5763.. \qquad N = 18.98415$

$\alpha = 71.1905681\ rad/s^2$

$w = w_0 + \alpha t \Rightarrow 15 = 0 + 71.1905681t \qquad \boxed{t = 0.2107\ s}$

CH17-DK-39 Intermediate Rotation (RBK) CHECK To be Completed

Inspiration: None



Draft wording:
If wheel A has a mass of $m = 15\ kg$, determine the horizontal force needed to lift wheel A off the ground.
The coefficient of kinetic friction between the two wheels is $\mu_k = 0.4$ and between the wheel and the ground is $\mu_k = 0.3$
$r = 0.3$ Doesn't rotate after contact

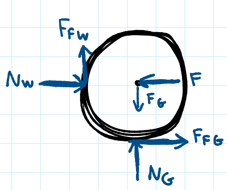
Should this static friction?

$\Sigma F_x = N_w - F + F_{FG} = N_w - F + 0.3N_G = 0$

$\Sigma F_y = 0.4N_w + N_G - (15)(9.81) = 0$

$I_G = \frac{1}{2}(15)(0.3)^2 = 0.675$

$\Sigma M_G = 0.675\alpha = 0 = F_{FG}(0.3) - F_{Fw}(0.3)$



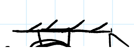
$0.4N_w + N_G = 147.15 \qquad N_G = 147.15 - 0.4N_w$

$N_w - F + 0.3N_G = 0 \qquad N_w + 44.145 -$

CH17-DK-40 Advanced Rotation (RBK) CHECK To be Completed

Inspiration: 17-74

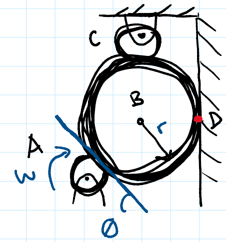
Need more apparent wording



The disk B has a mass of $m = 4\ kg$ and is originally at rest
when it is placed into contact with motor A, collar C, and the wall at D

Inspiration: 17-44

Need more apparent wording

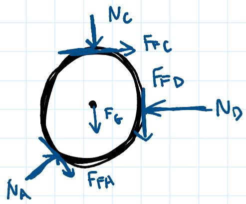


The disk B has a mass of $m = 4\ kg$ and is originally at rest when it is placed into contact with rotor A, roller C, and the wall at D. If disk B has a radius $r = 1\ m$ and rotor A spins at a constant $w = 6$ rad/s, determine the angular acceleration of disk B. The point of tangency between A and B is at angle of $\theta = 60°$ and the coefficient of kinetic friction is given as $\mu_k = 0.25$ between all contacting surfaces and coefficient of static friction $\mu_s = 0.3$

Roller C starts from rest

Rotor A was spinning before contact

$$I_B = \tfrac{1}{2}mr^2 = \tfrac{1}{2}(4)(1^2) = 2$$



C and B $\Rightarrow$ Rolling without slipping

A and B $\Rightarrow$ Rolling with slipping

D and B $\Rightarrow$ sliding

wait C doesn't actually apply a normal force tho does it?

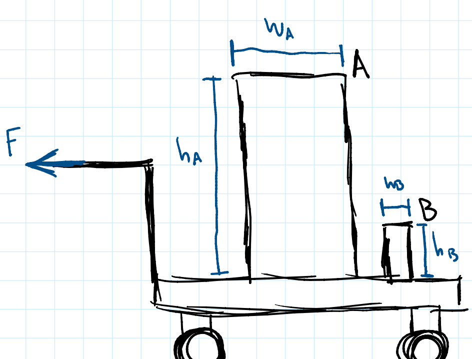
$$\Sigma F_x = N_A \sin 60 + 0.25 N_A \cos 60 - N_D + 0.3 N_C = 0$$

$$\Sigma F_y = N_A \cos 60 - 0.25 N_A \sin 60 - mg - 0.25 N_D - N_C = 0$$

$$\Sigma M_G = 2\alpha = -0.3 N_C (1) - 0.25 N_D (1) + 0.25 N_A (1)$$

CH17-DK-41 Intermediate Translation (RBK)

Inspiration: 17-37

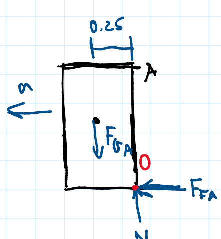


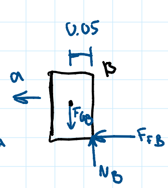
Your wonderful parents have returned from their vacation from Hawaii while you were studying for midterms. At the airport, you stack their luggage, which can be modelled as boxes A and B, on a cart. Box A has a width $w_A = 0.5\ m$ and height $h_A = 0.8$ while Box B has a width $w_B = 0.1\ m$ and height $h_B = 0.25$. If Box A has a mass of $m_A = 50\ kg$ and Box B has a mass $m_B = 10\ kg$, determine the maximum force F you can apply on the 12 kg cart before tipping either of the boxes over. Assume slipping does not occur.

Box A

$$\Sigma M_{AO} = (50)(9.81)(0.25) = m a_{Gx} \tfrac{h}{2} = (50) a_{Gx}(0.4)$$

$$a_{Gx_A} = 6.13125$$



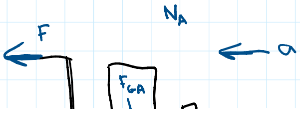


Box B

$$\Sigma M_{BO} = (10)(9.81)(0.05) = (10) a_{Gx}(0.125)$$

$$a_{Gx_B} = 3.924$$

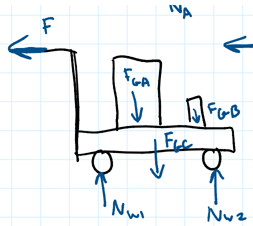
$a_{GxB} < a_{GxA}$ Box B will tip first



Cart C

$$\Sigma F_{x_C} = F = (50+10+12)(3.924) = \boxed{282.528\ N}$$ to tip box B

$$F = (50+10+12)(6.13125) = \boxed{441.45\ N}$$ to tip both box A and B



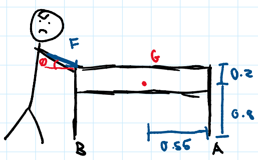
$\Sigma F_{x_C} = F = (50+10+12)(3.924) = \boxed{282.528\,N}$ to tip box B

$F = (50+10+12)(6.13125) = \boxed{441.45\,N}$ to tip both box A and B

CH17-DK-42 Intermediate Translation (RBK) CHECK

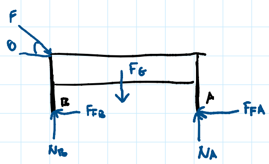
Inspiration: 17-36 Hibbeler

Cut Second Part → New problem maybe



Your mom is asking you to clean your room. Angrily, you apply exactly enough force on your desk to overcome static friction. Determine the initial acceleration of your desk at this state and normal forces at A and B

You are so livid you push even harder on the desk at which point it begins to tip. Determine the force you exerted to do so. The desk has a center of gravity at G, with a mass of 15 kg. The coefficient of static and kinetic friction is given as $\mu_s = 0.5$ and $\mu_k = 0.3$ respectively, and $\theta = 30°$



Static friction force:

$\Sigma F_x = F\cos 30 - F_{FB} - F_{FA} = F\cos 30 - 0.5N_B - 0.5N_A = 0$

$\Sigma F_y = N_B + N_A - F\sin 30 - (15)(9.81) = 0$

$N_B + N_A = F\sin 30 + 147.15$

$F\cos 30 - 0.5F\sin 30 - 73.575 = 0 \qquad F = 119.435\,N$

Sliding desk:

$\Sigma F_x = m a_{Gx}$

$\Sigma F_y = m a_{Gy} = 0$

$119.435\cos 30 - 0.3N_B - 0.3N_A = 15a_{Gx}$

$-119.435\sin 30 + N_B + N_A - 15(9.81) = 0$

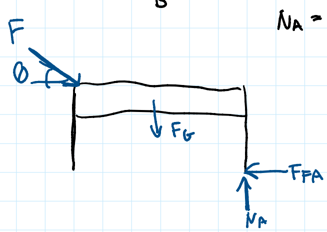
$N_B + N_A = 206.8675046$

$119.435\cos 30 - 62.06025 = 15a_{Gx} \qquad \boxed{a_{Gx} = 2.75823\,m/s^2}$

$\Sigma M_B = -119.435\cos 30(1) - (15)(9.81)(0.55) + N_A(1.1) = -(15)(2.75823)(0.8)$

$N_A = 137.51584\,N \qquad N_B = 69.35161$ Each leg $\boxed{N_B = 34.6758}$

$\boxed{N_A = 68.7579}$



Sliding then tipping:

$\Sigma F_x = F\cos 30 - 0.3N_A = 15a_{Gx}$

$\Sigma F_y = -F\sin 30 - (15)(9.81) + N_A = 15a_{Gy}$

$\Sigma M_A = -F\cos 30(1) + F\sin 30(1.1) + (15)(9.81)(0.55) = -(15)a_{Gx}(0.8)$

Don't think Physics works this way, nonsensical

CH17-DK-43 Intermediate Radius of Gyration

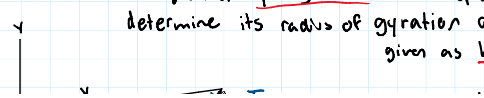
Inspiration: 17-7

Swap one of the intermediates to beginner

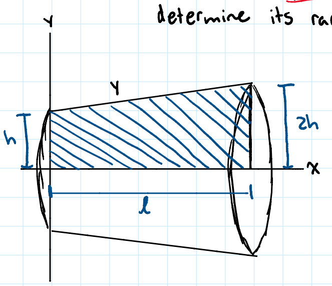
maybe an Advance depending on other's opinion

any better descriptive word?

An engineering student has modelled a solid cup CAD software by rotating the coloured area about the x-axis. If y can be described by the equation $y = \frac{1}{3}x + 1$ and the cup has constant density $\rho = 600\,kg/m^3$, determine its radius of gyration about the x axis. The cup dimensions are given as $h = 1\,m$ and $\ell = 3\,m$



determine its radius of gyration about the x axis. The cup dimensions are given as $h = 1\,m$ and $l = 3\,m$



$dm = \rho\, dV$ dV depends on dx and the value of y at that instance

$= \rho \underbrace{\pi y^2}_{\text{area}} \underbrace{dx}_{\text{height}} = \rho\pi(\frac{1}{3}x+1)^2 dx = \rho\pi(\frac{1}{9}x^2 + \frac{2}{3}x + 1)\,dx$

Rotating about x-axis $\Rightarrow$ much like ring or disk $I_x = \frac{1}{2}mr^2$ ← radius is y in this case

$dI_x = \frac{1}{2}dm\,y^2 = \frac{1}{2}\rho\pi(\frac{1}{9}x^2+\frac{2}{3}x+1)(\frac{1}{9}x^2+\frac{2}{3}x+1)\,dx$

$= \frac{1}{2}\rho\pi\left(\frac{1}{81}x^4 + \frac{2}{27}x^3 + \frac{1}{9}x^2 + \frac{2}{27}x^3 + \frac{4}{9}x^2 + \frac{2}{3}x + \frac{1}{9}x^2 + \frac{2}{3}x + 1\right)dx$

$= 300\pi\,(\frac{1}{81}x^4 + \frac{4}{27}x^3 + \frac{2}{3}x^2 + \frac{4}{3}x + 1)\,dx$

$I_x = \int dI_x = 300\pi \int_0^3 \frac{1}{81}x^4 + \frac{4}{27}x^3 + \frac{2}{3}x^2 + \frac{4}{3}x + 1\,dx$

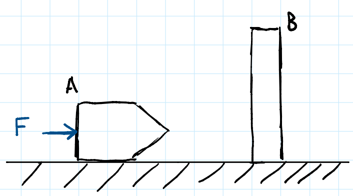
$= 300\pi(18.6) = 5580\pi = 17530.08701$

$m = 600\pi \int_0^3 \frac{1}{9}x^2 + \frac{2}{3}x + 1\,dx = 600\pi(7) = 4200\pi = 6597.344573$

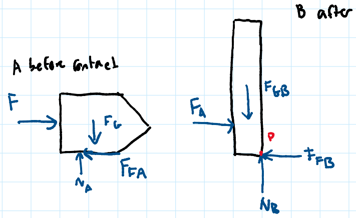
$k_x = \sqrt{\frac{I_x}{m}} = \sqrt{\frac{5580\pi}{4200\pi}} = \boxed{1.152636}$

CH17-DK-44   Beginner   Multibody Kinetics   Lol check Please

Inspiration: None   Not sure if the no-slipping, no-tipping solution is apparent



Determine the applied force F required on wedge A in order to cause block B to slip or tip if the coefficient of static and kinetic friction are given as $\mu_s = 0.3$ and $\mu_k = 0.2$ respectively. Wedge A contacts block B at a height $h_A = 0.1\,m$ and block B has a width $w_B = 0.05$ and height $h_B = 0.45\,m$. Both A and B have a mass of $m = 0.5\,kg$



$\sum F_{Ax} = ma_{Gx} = F_A = F - 0.2N_A$

$\sum F_{Ay} = 0 = N_A - mg$ $N_A = 0.5(9.81) = 4.905$

$F_A = F - 0.2(4.905) = F - 0.981$

No slipping:

$\sum F_{Bx} = F_A - F_{FB} = 0$ $F_A = 0.3N_B$ $F_A = 1.4715$

$\sum F_{By} = N_B - F_{GB} = 0$ $N_B = 0.5(9.81) = 4.905$

No tipping:

$\sum M_P = 0 = -F_A(0.1) + 0.5(9.81)(0.025) = 0$

$F_A = 1.22625$ $1.22625 < 1.4715$

Block B will tip first

$F_A = 1.22625 = F - 0.981$ $\boxed{F = 2.20725\,N}$