

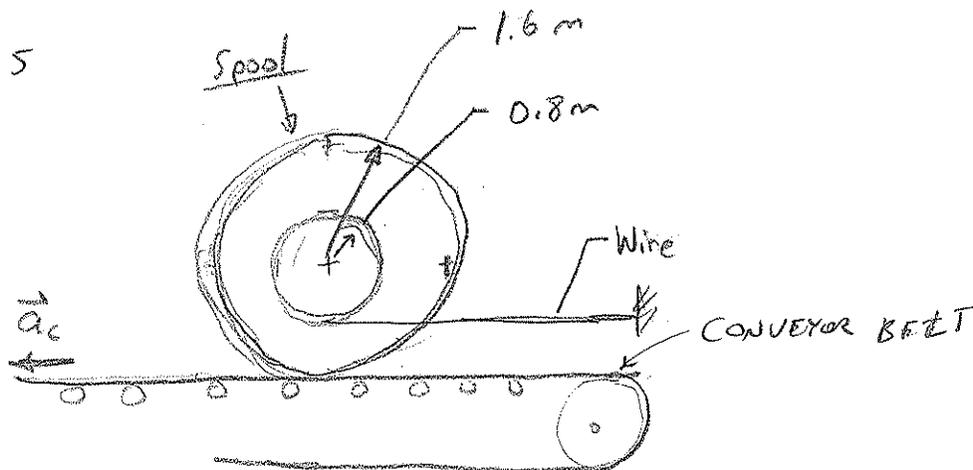
SITUATION

SPOOL ON A MOVING CONVEYOR BELT
 SPOOL AT REST ($t=0s$); NO SLIP ON CONVEYOR BELT

$m = 500 \text{ kg}$

$k_G = 1.3 \text{ m}$

$\mu_s = 0.5$



GOALS

① $\vec{a}_c \text{ (m/s}^2\text{)}$ ← mag of accel. of conveyor belt
 so spool does not slip

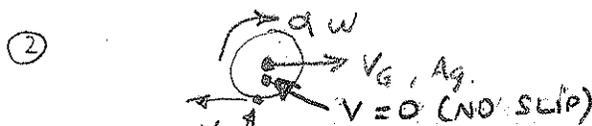
② $\vec{T} \text{ (N)}$ ← tension in the wire at ($t=0s$)

③ $\vec{d} \text{ (rad/s}^2\text{)}$ ← spool ang. accel. at $t=0s$

IDEAS

① NO SLIP: $(v_G) = v_{\text{inside}}$ ← ② WIRE/SPOOL INTERFACE.

Rolling w/o slipping at belt

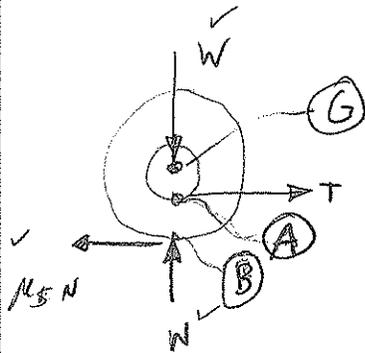


3 RB Kinetics eqns.

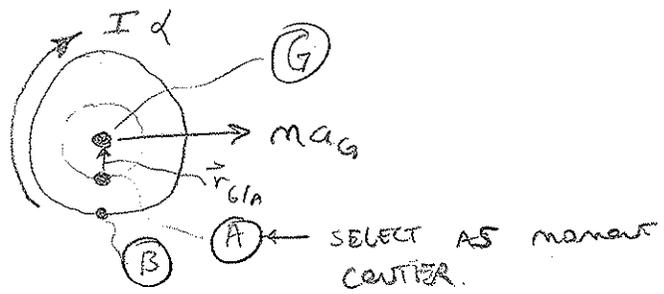
③ \vec{a}_G > relate using RB accel. eqn.

so N PATH ENDED UP INVOLVING ALL 5 OF THESE EQNS.

① FBO



KD



$$\sum M_A = I_G \alpha + (\vec{r}_{G/A} \times m \vec{a}_G)_z$$

NEWTON'S 2nd Law

(↑+) $-W + N = m(a_G)_y \Rightarrow \vec{W} = N$

(→+) $T - \mu_s N = m(a_G)_x = \vec{m} a_G$

ROTATION Law (about A)

(↺) $\mu_s N (0.8m) = I_G \alpha + m a_G (0.8)m$

3
T, a_G, α
3 UNKS
2 EQNS
∴ NE

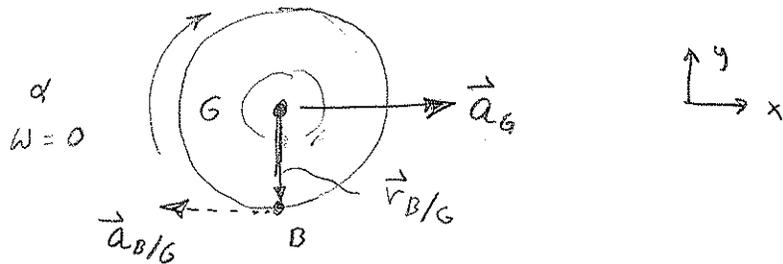
Rolling w/o slipping (at A)

$a_G = (0.8m) \alpha$ ①

∴ solve ①/② for α & a_G
③ for T

RB accel eqn. (A ≠ B) $\vec{a}_C = \vec{a}_B$

$\vec{a}_B = \vec{a}_G + (\vec{a}_{B/G})_T + (\vec{a}_{B/G})_N$ 0: ω = 0



$$\therefore \vec{a}_B = \vec{a}_C = a_G \uparrow - (r_{B/G} \alpha) \uparrow$$

$$- a_C = \vec{a}_G - (1.6\text{m}) \ddot{\alpha} \quad \boxed{4}$$

PLAN.

- ① calc. I_G, W
- ② combine $\boxed{1}, \boxed{2} \Rightarrow$ solve for α .
- ③ solve $\boxed{1}$ for a_G ✓
- ④ solve $\boxed{3}$ for T
- ⑤ solve $\boxed{4}$ for a_C

ANSWER.

PROGRAM IN TKS SOLVER
[see next page]

$$\vec{a}_C = 1.35 \text{ m/s}^2 \leftarrow$$

$$\vec{T} = 3130 \text{ N} \rightarrow$$

$$\vec{\alpha} = 1.684 \text{ rad/s}^2 \curvearrowright$$

REVIEW

- EXPLAINING WHAT/WHY = CHALLENGE.
- 50+ MINUTES FOR A PROBLEM LIKE THIS IS NEEDED
- COMMIT TO PRODUCING GREAT DOC = 100%
- (A) \leftarrow denote a point or location (circle)
- T \leftarrow denote a variable



REPORT

Hibbler 17.94

Variables Sheet

Input	Name	Output	Unit	Comment
1.3	k_G		m	
1.6	ro		m	
.5	mu_s		()	
500	m		kg	
9.81	g		m/s^2	
	I_G	845	kg*m^2	
	W	4905	N	
	a_G	1.347296	m/s^2	
	alpha	1.684120	rad/s^2	
	T	3126.148069	N	
	a_C	1.347296	m/s^2	

Rules Sheet

Rules

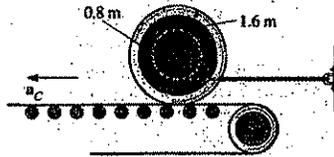
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; Hibbler 17.94 (11e) || DFE || 5/13/09 ||
I_G=k_G^2 * m
W=m * g
a_G=0.8 * alpha
mu_s * W * .8=I_G * alpha + m * a_G * 0.8
T - mu_s * W = m * a_G
-a_C = a_G - 1.6 * alpha

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17-93. The spool has a mass of 500 kg and a radius of gyration $k_G = 1.30$ m. It rests on the surface of a conveyor belt for which the coefficient of static friction is $\mu_s = 0.5$ and the coefficient of kinetic friction is $\mu_k = 0.4$. If the conveyor accelerates at $a_C = 1$ m/s², determine the initial tension in the wire and the angular acceleration of the spool. The spool is originally at rest.



$$\rightarrow \sum F_x = m(a_G)_x; \quad -F_s + T = 500a_G$$

$$+\uparrow \sum F_y = m(a_G)_y; \quad N_s - 500(9.81) = 0$$

$$\curvearrowleft + \sum M_G = I_G \alpha; \quad F_s(1.6) - T(0.8) = 500(1.30)^2 \alpha$$

$$a_P = a_G + a_{P/G}$$

$$(a_P)_j = a_G i - 0.8 \alpha i$$

$$a_G = 0.8 \alpha$$

$$N_s = 4905 \text{ N}$$

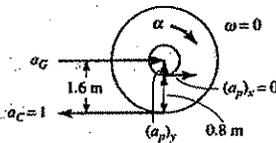
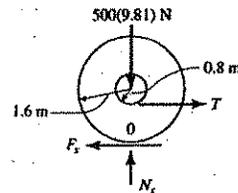
Assume no slipping

$$\alpha = \frac{a_C}{0.8} = \frac{1}{0.8} = 1.25 \text{ rad/s} \quad \text{Ans}$$

$$a_G = 0.8(1.25) = 1 \text{ m/s}^2$$

$$T = 2.32 \text{ kN} \quad \text{Ans}$$

$$F_s = 1.82 \text{ kN}$$



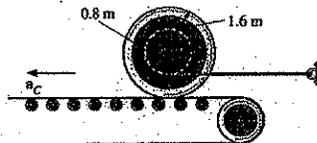
Since

$$(F_s)_{\max} = 0.5(4.905) = 2.45 > 1.82$$

(No slipping occurs)

HIBBLER SOLN

17-94. The spool has a mass of 500 kg and a radius of gyration $k_G = 1.30$ m. It rests on the surface of a conveyor belt for which the coefficient of static friction is $\mu_s = 0.5$. Determine the greatest acceleration a_C of the conveyor so that the spool will not slip. Also, what are the initial tension in the wire and the angular acceleration of the spool? The spool is originally at rest.



$$\rightarrow \sum F_x = m(a_G)_x; \quad T - 0.5N_s = 500a_G$$

$$+\uparrow \sum F_y = m(a_G)_y; \quad N_s - 500(9.81) = 0$$

$$\curvearrowleft + \sum M_G = I_G \alpha; \quad 0.5N_s(1.6) - T(0.8) = 500(1.30)^2 \alpha$$

$$a_P = a_G + a_{P/G}$$

$$(a_P)_j = a_G i - 0.8 \alpha i$$

$$a_G = 0.8 \alpha$$

Solving;

$$N_s = 4905 \text{ N}$$

$$T = 3.13 \text{ kN} \quad \text{Ans}$$

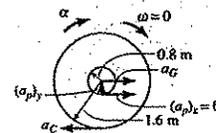
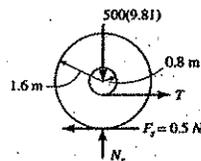
$$\alpha = 1.684 \text{ rad/s} \quad \text{Ans}$$

$$a_G = 1.347 \text{ m/s}^2 \quad \text{Ans}$$

Since no slipping

$$a_C = a_G + a_{C/G}$$

$$a_C = 1.347 + (1.684)(1.6)$$



$$a_C = 1.35 \text{ m/s}^2 \quad \text{Ans}$$

Also,

$$\curvearrowleft + \sum M_{IC} = I_{IC} \alpha; \quad 0.5N_s(0.8) = [500(1.30)^2 + 500(0.8)^2] \alpha$$

Since $N_s = 4905$ N

$$\alpha = 1.684 \text{ rad/s}$$