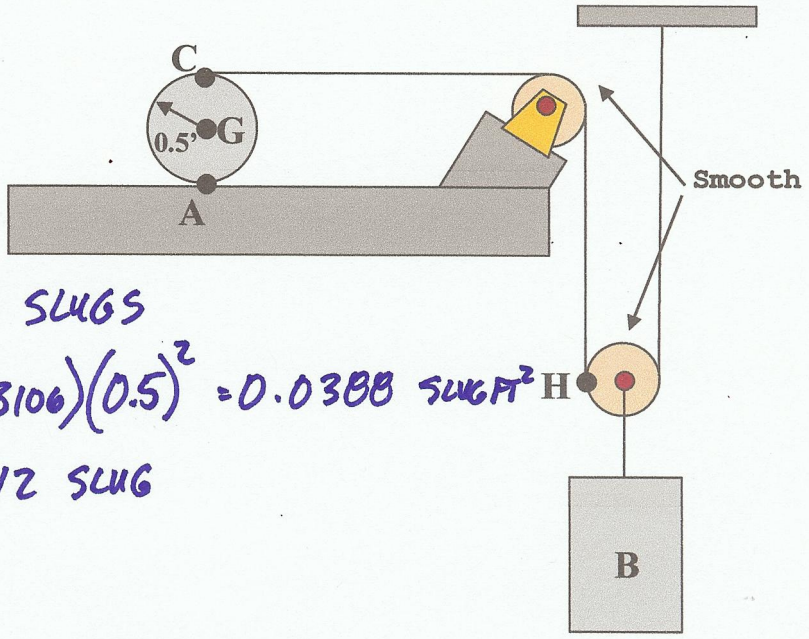
Force Acceleration III – Problem 3

The 10-lb disk and the 4-lb block are released from rest. Determine the velocity of the block when t = 3 s. The coefficient of static friction at A is $\mu_s = 0.2$. Neglect the mass of the cord and the pulleys.



CLASSIFY MOTION

DISK - GPM

BLOCK - TRANS

PROPERTIES

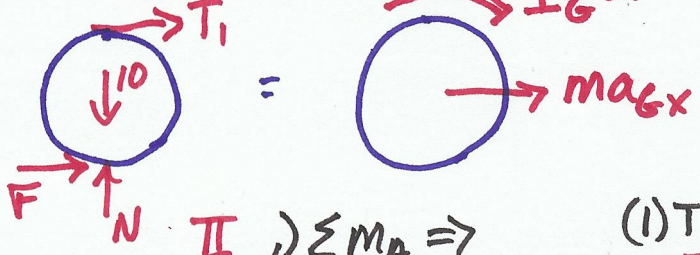
$m_D = \frac{10}{g} = 0.3106$ SLUGS

$I_{GD} = \frac{1}{2}mr^2 = \frac{1}{2}(.3106)(0.5)^2 = 0.0388$ SLUG FT^2

$m_B = \frac{4}{g} = 0.1242$ SLUG

$\mu_s = 0.2$

FBD = KD



(HELP)

ASSUME NO SLIP

$a_{Gx} = \alpha r = 0.5\alpha$ EQN I

II $\circlearrowleft \Sigma M_A \Rightarrow$

III $\uparrow \Sigma y \Rightarrow$

IV $\rightarrow \Sigma x \Rightarrow$

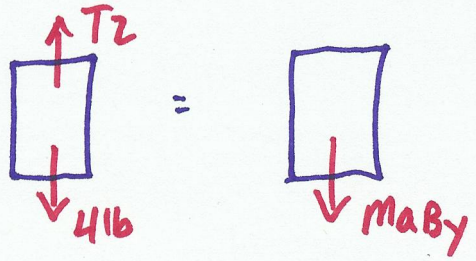
(I) $T_1 = I_G\alpha + 0.5\, ma_{Gx} = 0.0388\alpha + .5(.3106)a_{Gx}$

$-10 + N = 0 \qquad N = 10$ lbs $\uparrow$

$F + T_1 = ma_{Gx} = 0.3106\, a_{Gx}$

3 EQNS, 4 UNKS (USED EQ III TO FIND N)

(MORE HELP) FBD = KD

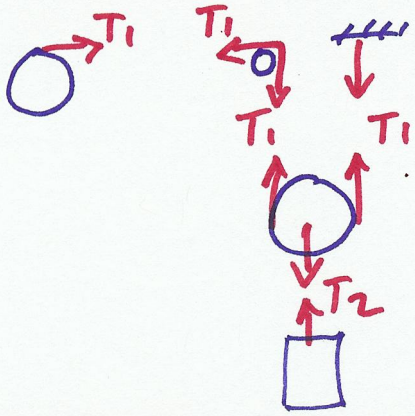


V $\uparrow \Sigma y \Rightarrow \quad T_2 - 4 = -.1242\, a_{By}$

4 EQNS, 6 UNKS

Force Acceleration III – Problem 3 continued

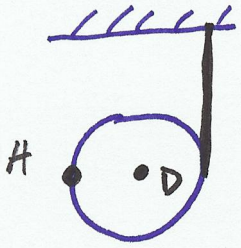
CONSIDER CABLES (MORE HELP)



VI $T_2 = 2T_1$

5 EQN, 6 UNKS

KINEMATICS OF NOO SLIP WHEEL (MORE HELP)



VII $a_D = \alpha_{DH} r$

VIII $a_D = a_{BY}$

RELATIVE ACC'N EQN

$a_H = a_D + a_{H/D}$ ZERO, RELEASED FROM REST

a_{HY} ↑, a_{HX} → $= \downarrow \alpha_{DH} r + \rightarrow \omega^2 r + \alpha r$

$\alpha_{DH} r$

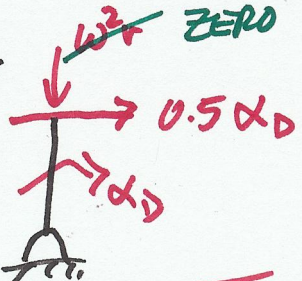
IX $\uparrow a_{HY} = -\alpha_{DH} r - \alpha_D r = -2a_D$

8 EQNS, 9 UNKS

MORE KINEMATICS (MORE HELP) (NO SLIP)

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

a_{Cy} ↑, a_{Cx} → $= 0.5\alpha_D \rightarrow + \omega^2$ ZERO, $0.5\alpha_D$ →, α_D



→ X $a_{Cx} = 2\alpha_D(.5) = 2a_{Gx}$

AND XI $a_{Cx} = a_{HY}$

10 EQNS

10 UNKS

Force Acceleration III – Problem 3 continued

USING VI, VII, XI + VIII REDEFINE ALL ACC'NS IN TERMS OF a_{BY}

$$a_{HY} = 2a_{BY}$$

$$a_{CX} = 2a_{BY}$$

$$a_G = a_{BY}$$

$$\alpha_{DISK} = \frac{a_G}{0.5} = 2a_{BY}$$

REMAINING EQNS

II $T_1 = 0.0388(2a_{BY}) + 0.3106a_{BY}(.5)$

IV $F + T_1 = 0.3106\, a_{BY}$

V $T_2 - 4 = -0.1242\, a_{BY} = 2T_1 - 4$

RE ARRANGE

$$T_1 - 0.2329\, a_{BY} = 0$$

$$T_1 - 0.3106\, a_{BY} + F = 0$$

$$2T_1 + 0.1242\, a_{BY} = 4$$

$$\begin{bmatrix} 1 & -.2329 & 0 \\ 1 & -.3106 & 1 \\ 2 & .1242 & 0 \end{bmatrix} \begin{Bmatrix} T_1 \\ a_{BY} \\ F \end{Bmatrix} = \begin{Bmatrix} 0 \\ 0 \\ 4 \end{Bmatrix}$$

$T_1 = 1.579$ lb

$a_{BY} = 6.78$ ft/s^2

$F = 0.527$ lb

CHECK NO SLIP ASSUMPTION

$F_{max} = \mu_s N = 0.2(10) = 2$

$F = 0.527 < 2 = F_{max}$

Assumption Good!

$$\int a\,dt = V(t) \Rightarrow \int_0^3 6.78\,dt = 6.78t\Big|_0^3 = 20.3 \text{ Fps} \downarrow$$