

$$a_G^x = a_B^x r_{B/G}$$

kinematic relation

$$a_B^x = 1.5d \quad a_B^y = a_{Gy}$$

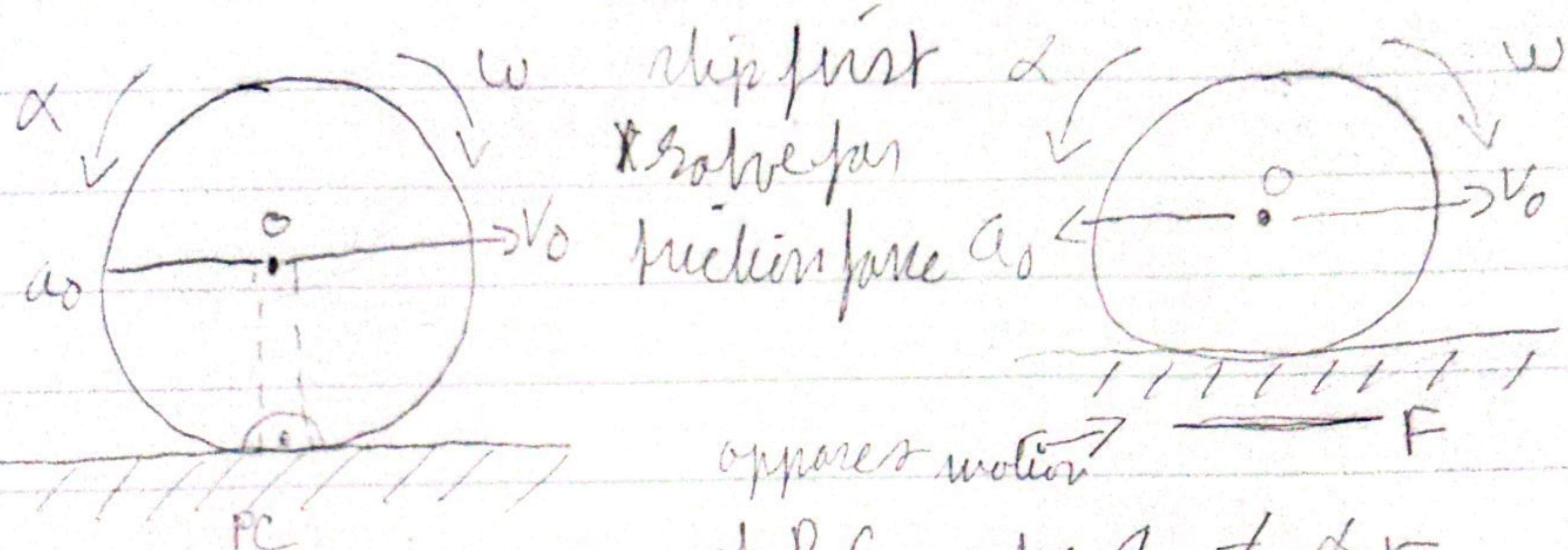
$$a_{Gy} = 1.5d$$

$$v_{A/B} = a_B^x / 6$$

No slip: kinematic

Slipping:

* assume no



w slip first &

* above far

fiction force a_0

opposite motion

of P.C. note $a_0 \neq a_r$

($v_0 \neq wr$), two objects move

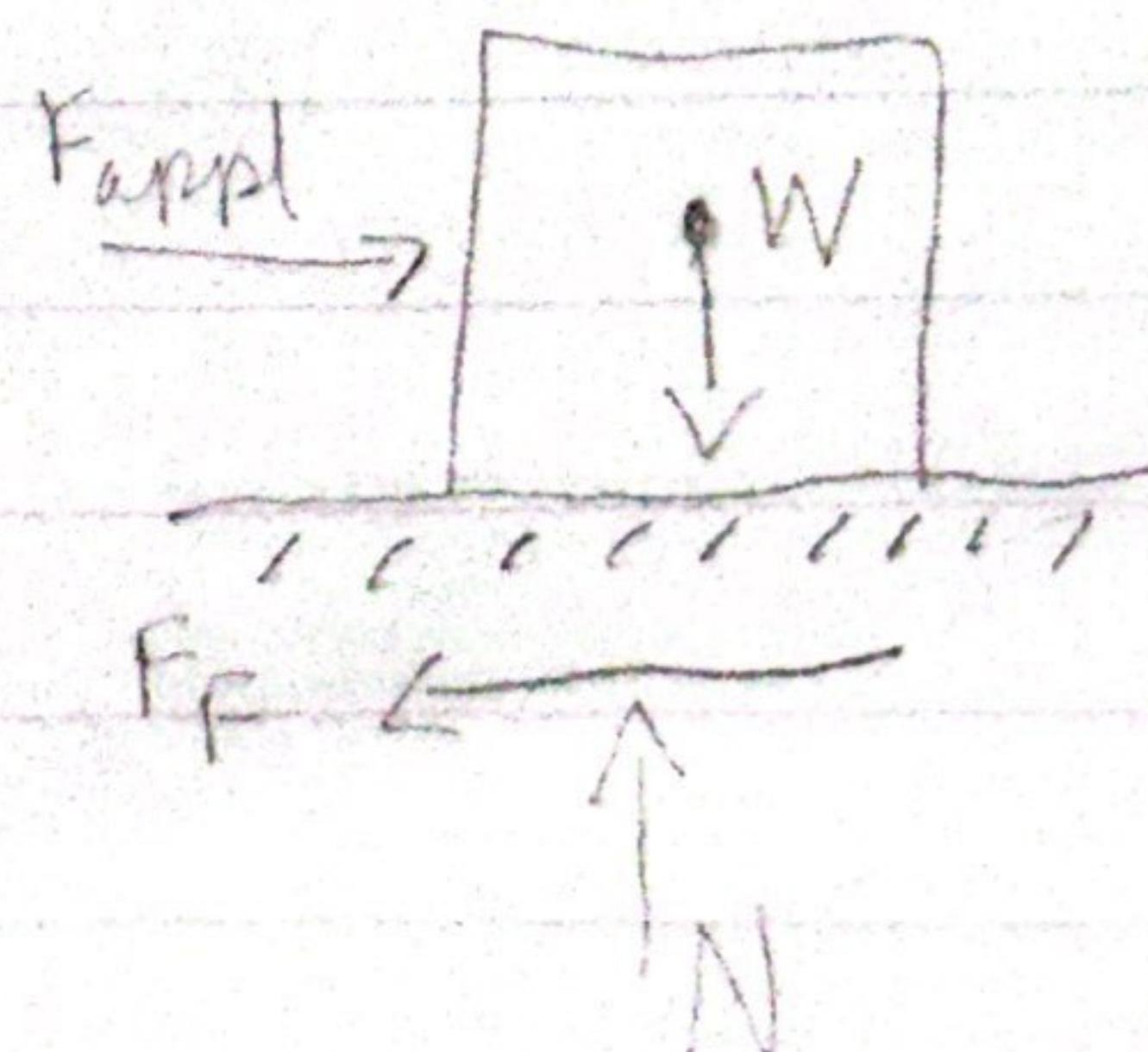
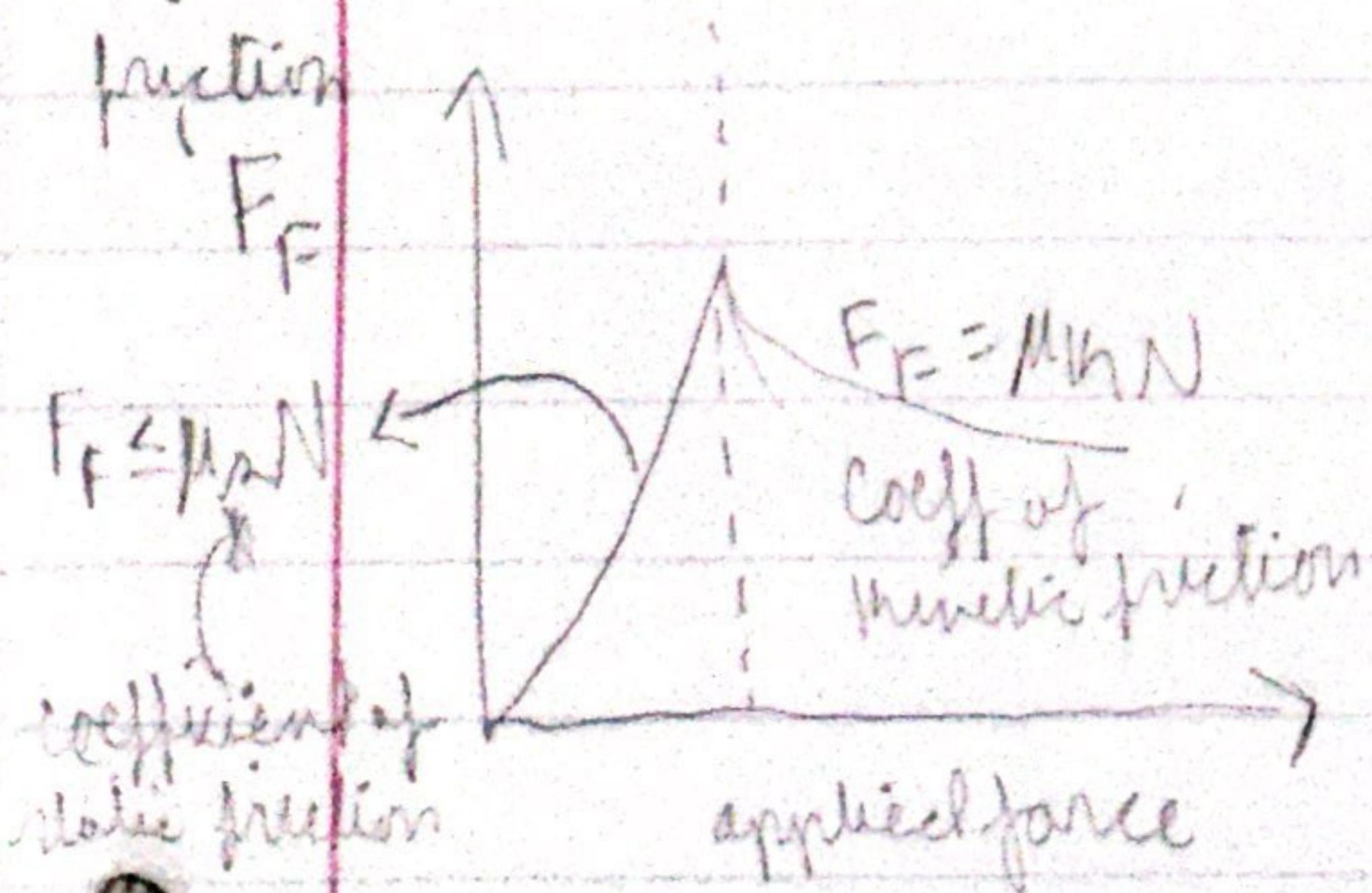
$F_f = \mu_s N$, over each other

F if no, then use this

✓ * $a_0 = dr$

$v_0 = wr$

solve $F \leq \mu_s N$ if yes
whether



Force acceleration II: problem



Two objects moving
over each other
 $F_F = \mu_{kN}$

Frictional assumption to start
the problem, always assume no slip

Radius of gyration $R_g = 0.25\text{m}$

$$\Rightarrow I_g = mR_g^2$$

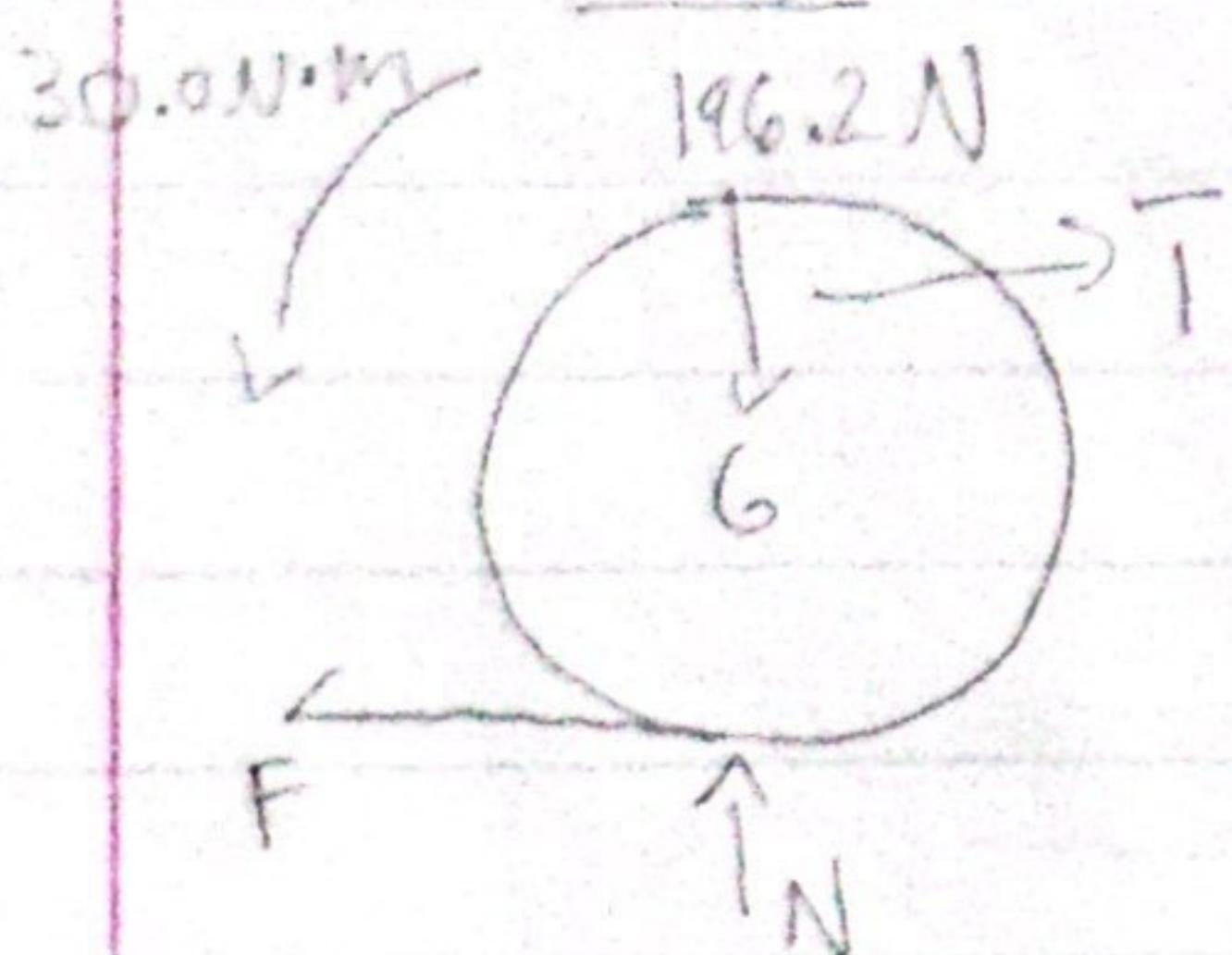
Classify motion:

$$m = 20\text{kg}$$

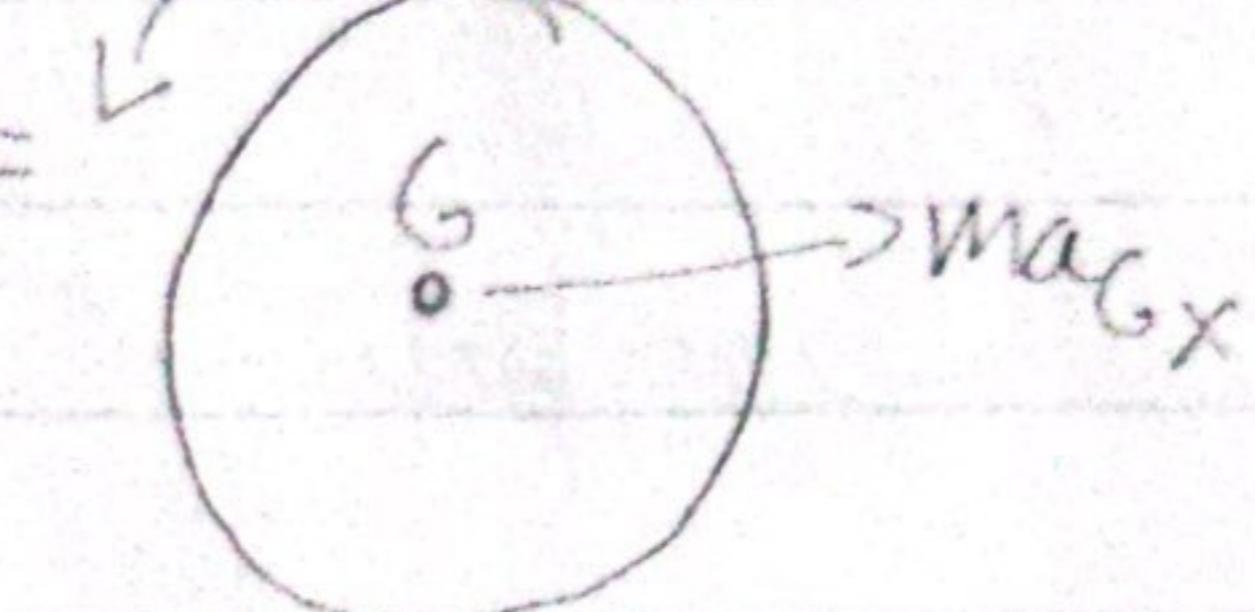
$$I_g = mR_g^2 = (20)(0.25)^2 = 1.25$$

$$w = Mg = (20)(9.81) = 196.2$$

FBD



KD
 $\frac{vd}{I_g \alpha}$



$$\rightarrow \sum F_x: -F + T = Ma_gx = 20 a_gx$$

must be slipping $\therefore F = \mu_{kN} = 0.1(196.2) = 19.62\text{N}$
at ground

Statics:

$$+ \sum F_x = 0$$

$$\sum F_y = 0$$

$$\sum M_G = 0$$

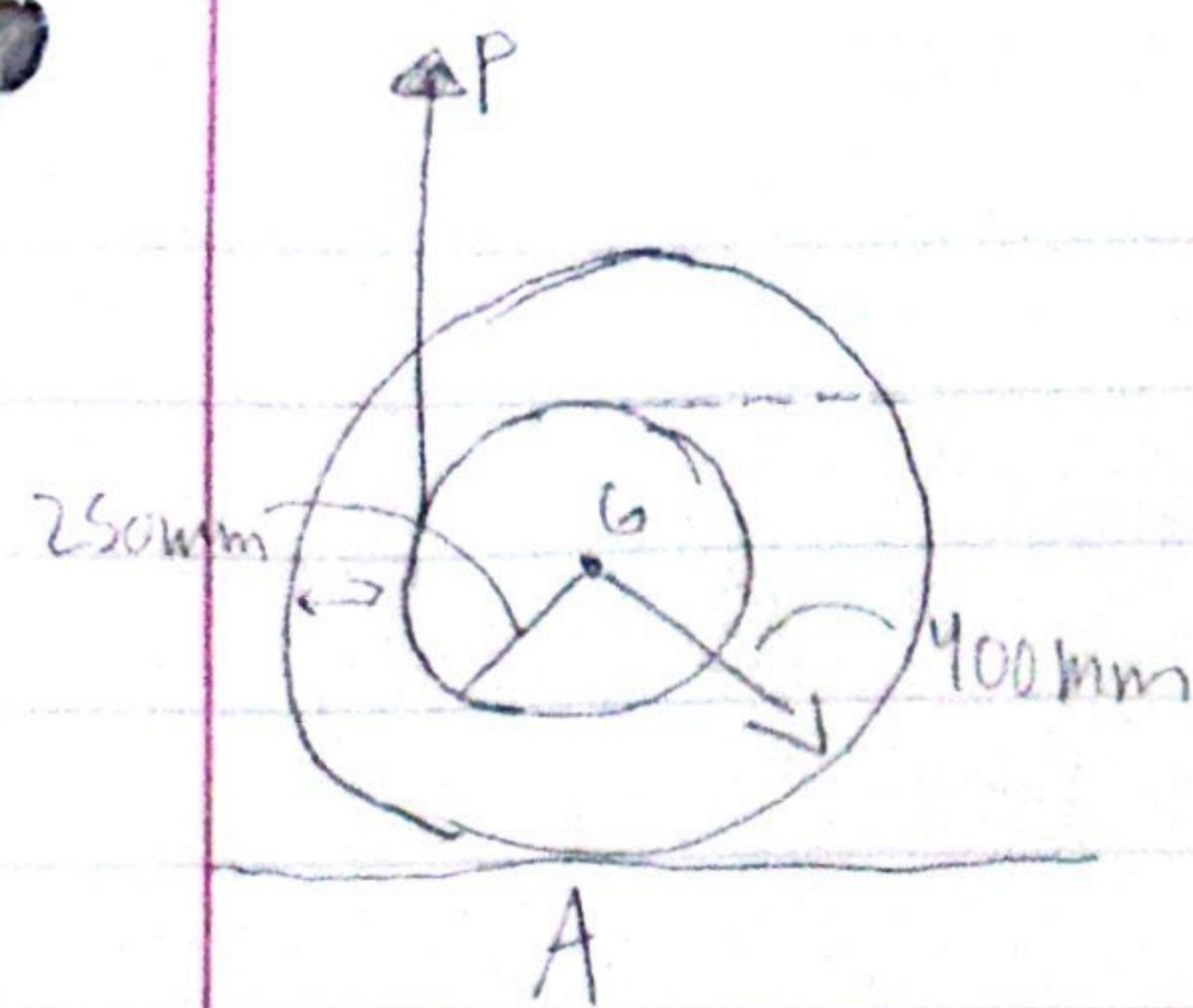
Dynamics:

$$+ \sum F_x = ma_gx$$

$$\sum F_y = ma_gy$$

$$\sum M_G = I_{G,d}$$

force acceleration III : problem 1



$$m = 10 \text{ kg}$$

radius of gyration $R_G = 0.3 \text{ m}$, $d_1 = 0.25 \text{ m}$

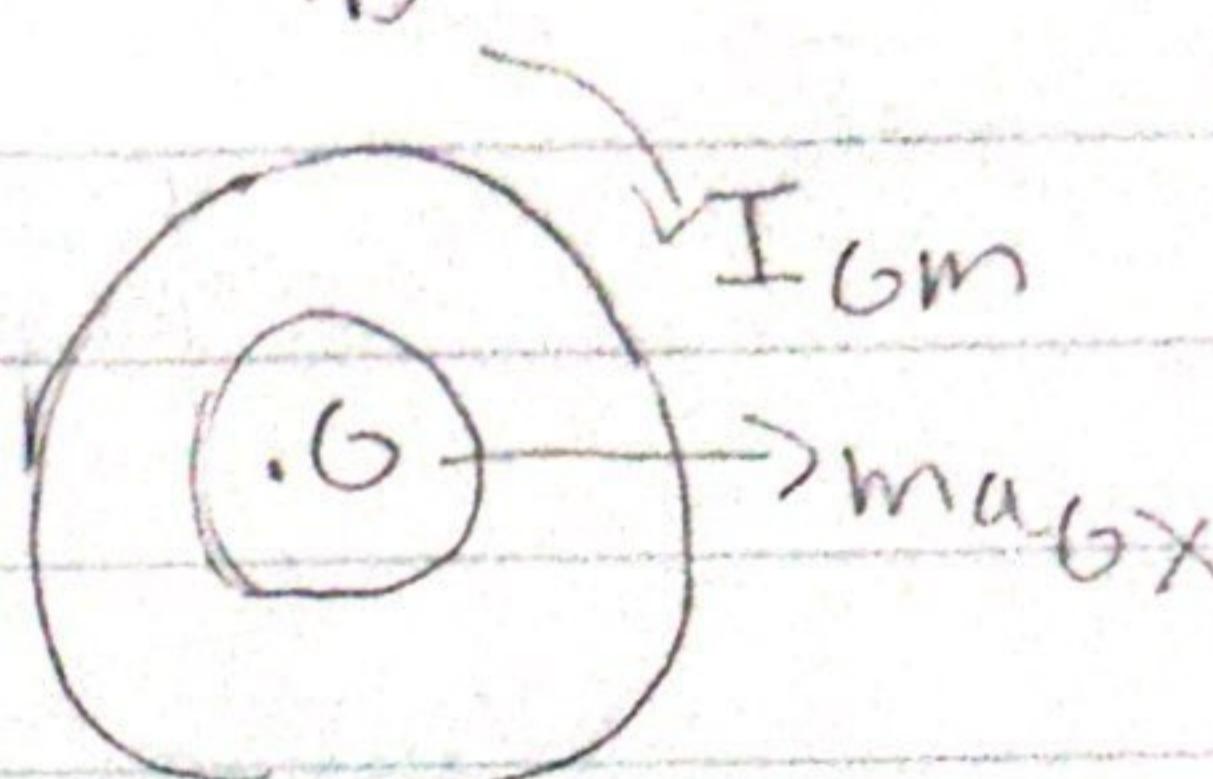
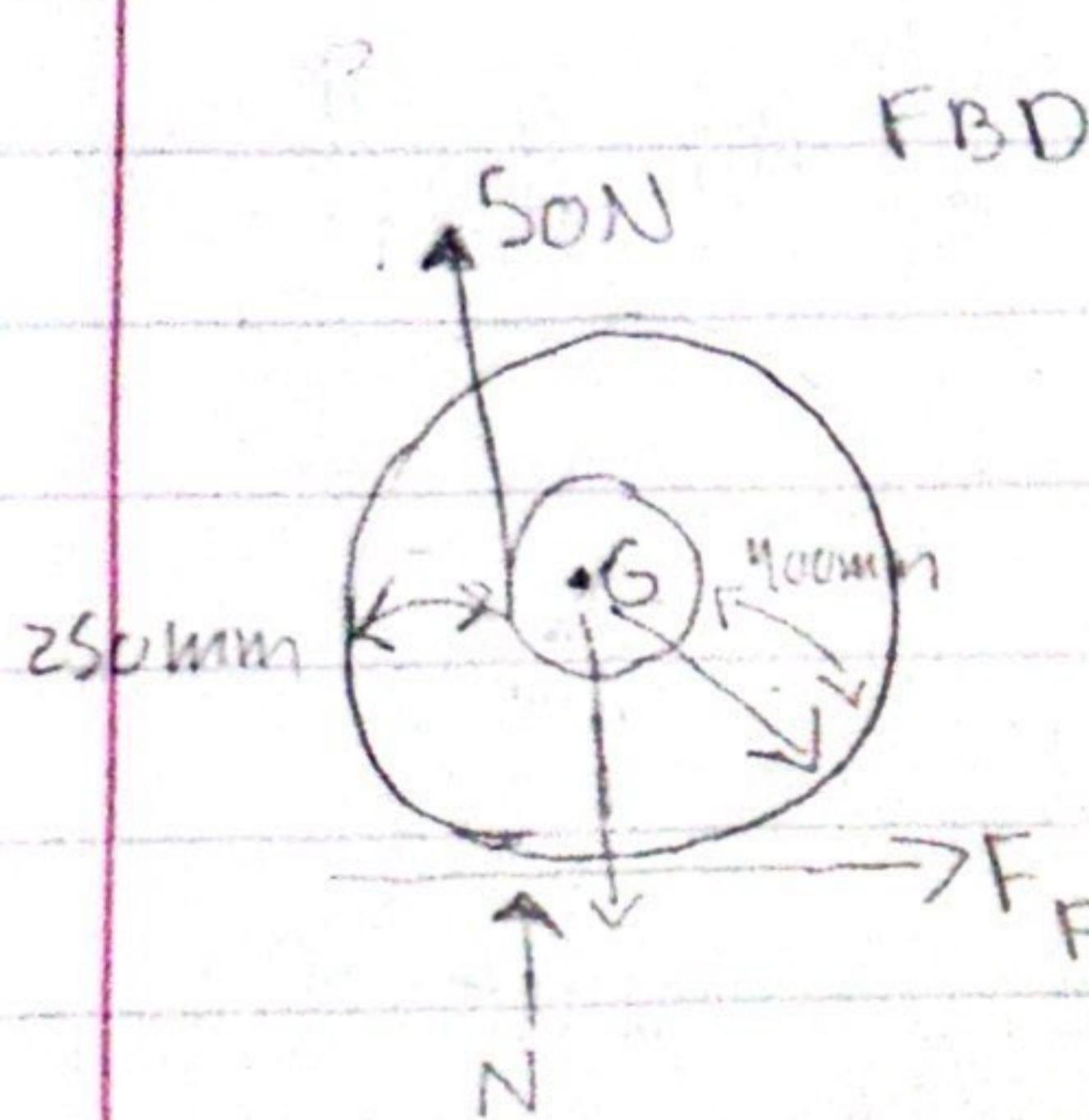
$$\mu_s = 0.2, \mu_k = 0.15, P = 50 \text{ N}, d_2 = 0.4 \text{ m}$$

$$1 rpm$$

$$I_G = mr^2 = (10)(0.3)^2 = 0.9$$

$$w = mg = (10)(9.81) = 98.1$$

$$a_0 = \omega r = (9.81)(0.4) = 3.924$$



$$1) \sum F_y \Rightarrow S_0 - 98.1 + N = 0 \quad N = 48.1$$

$$2) \sum F_x \Rightarrow F = ma_{Gx} = 10a_{Gx} = 10(0.4\alpha)$$

$$3) \sum M_G \Rightarrow -S_0(0.25) + F(0.4) = -0.9\alpha$$

$$\text{assume non-slip} \quad F = 4\alpha$$

$$a_{Gx} = \alpha r = 0.4\alpha \quad -S_0(0.25) + (0.4\alpha)/0.4 = -0.9\alpha \\ \alpha = 5.01 \text{ rad/s}^2$$

$$a_{Gx} = 0.4\alpha = 2.0 \text{ m/s}^2 \quad F = 10a_{Gx} = 20.0 \text{ N}$$

$$F_{max} = \mu_s N = 0.2(48.1) = 9.62 \text{ N}$$

$F > F_{max} \therefore$ slipping

$$F = \mu_k N = 0.15(48.1) = 7.21 \text{ N}$$

$$-S_0(0.25) + F(0.4) = -0.9\alpha$$

$$-S_0(0.25) + 7.21(0.4) = -0.9\alpha$$

$$\boxed{\alpha = 10.68 \text{ rad/s}^2}$$

Force acceleration



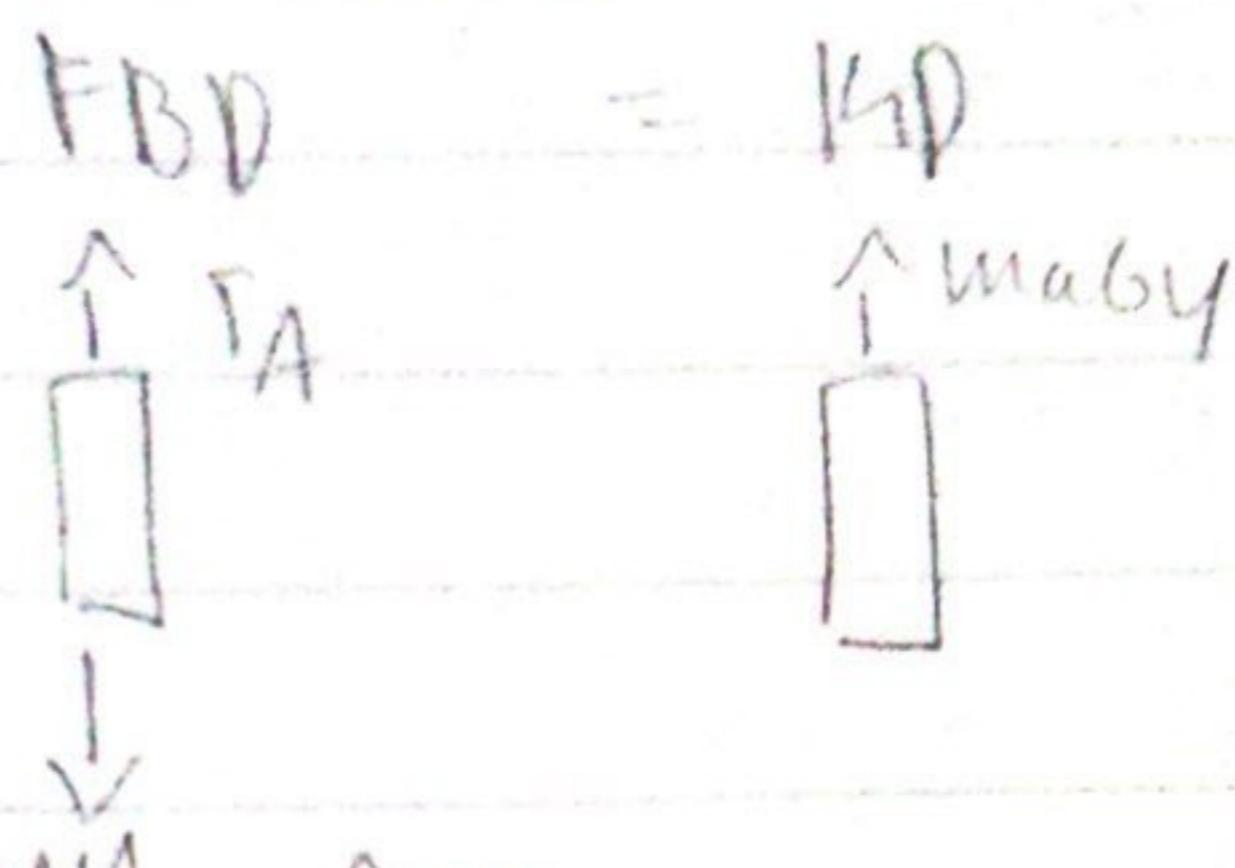
$$m_A = 5 \text{ kg}$$

$$m_B = 10 \text{ kg}$$

$$m_{\text{pulley}} = 3 \text{ kg}$$

$$r = 0.15 \text{ m}$$

Block A:



$$a = dr$$

$$\uparrow \sum F_y = m_A g_y$$

$$T_A - W_A = m_A g_y \quad \Delta r$$

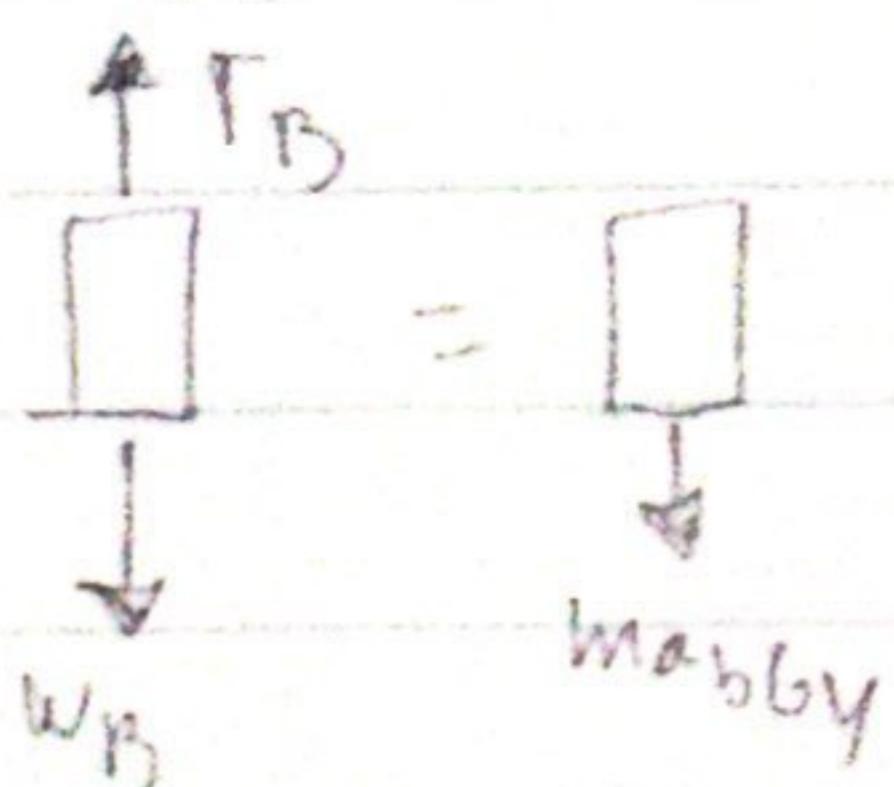
$$T_A - (5 \text{ kg})(9.81) = 5 \text{ kg} a_r$$

$$T_A - 49 = (5 \text{ kg})(0.15 \text{ m}) a$$

$$\textcircled{1} \quad T_A = 0.75 a + 49$$

Block B:

FBD = ND $\uparrow \sum F_y = m_B g_y$



$$T_B - W_B = -m_B g_y$$

$$T_B - (10 \text{ kg})(9.8) = -(10 \text{ kg}) a_r$$

$$T_B - 98 = -(10 \text{ kg}) a (0.15 \text{ m})$$

$$T_B = -1.5 a + 98$$

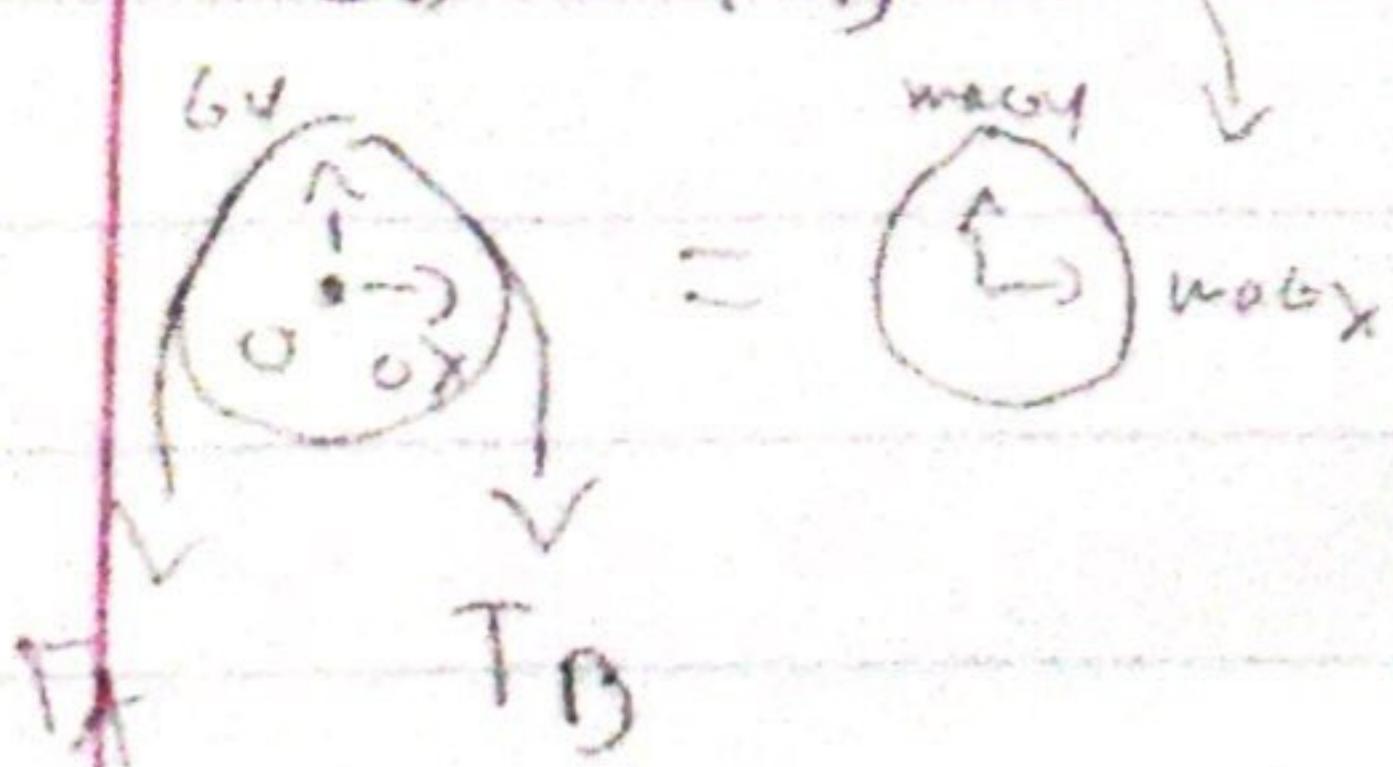
$$I_0 = \frac{1}{2} m(r^2)$$

$$\frac{1}{2} (3)(0.15)^2$$

Drum

$$\ell \sum M_0 = I_0 a \quad T_B (0.15 \text{ m}) - T_A (0.15 \text{ m}) = I_0 a$$

FBD = ND $\uparrow I_0 a$



$$T_B - T_A = \frac{1}{2} (3)(0.15) a$$

$$T_B - T_A = 0.225 a$$

$$T_B - T_A = 0.225 a$$

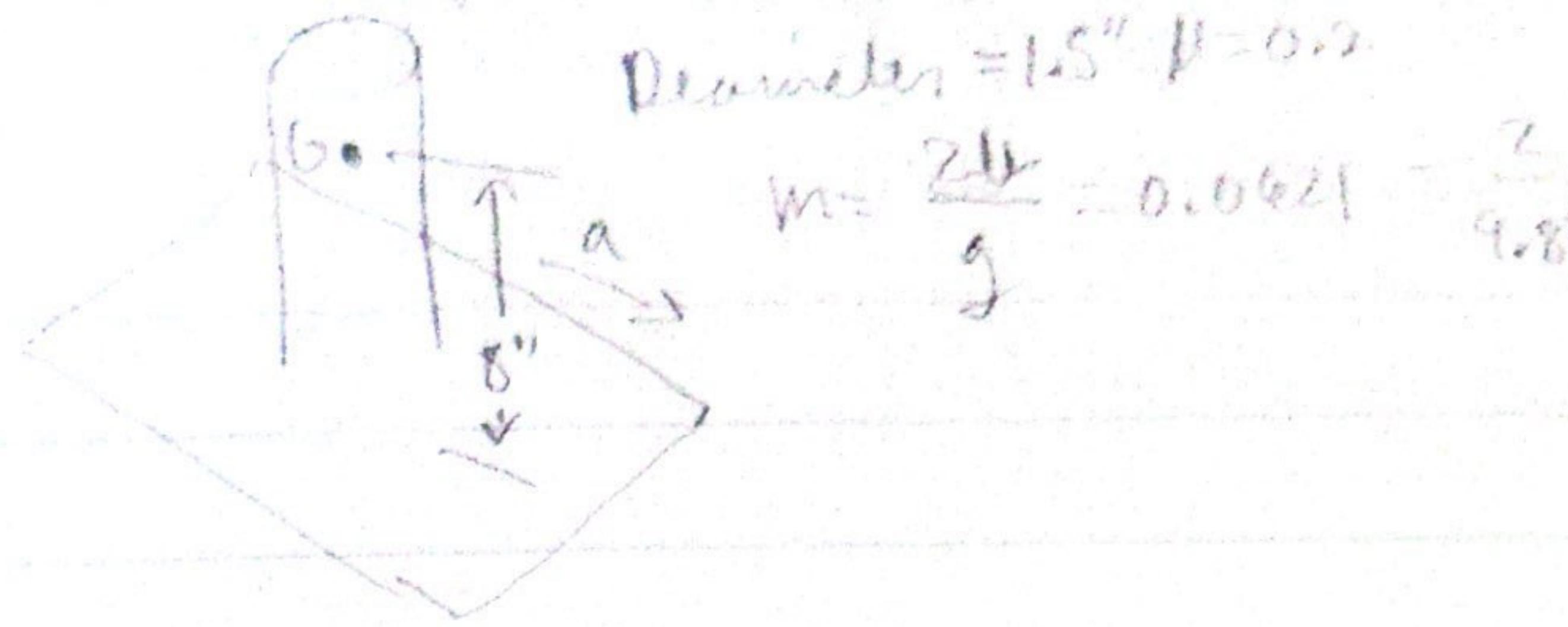
$$-1.5 a + 98 - (0.75 a + 49) = 0.225 a$$

$$\boxed{a = 19.798}$$

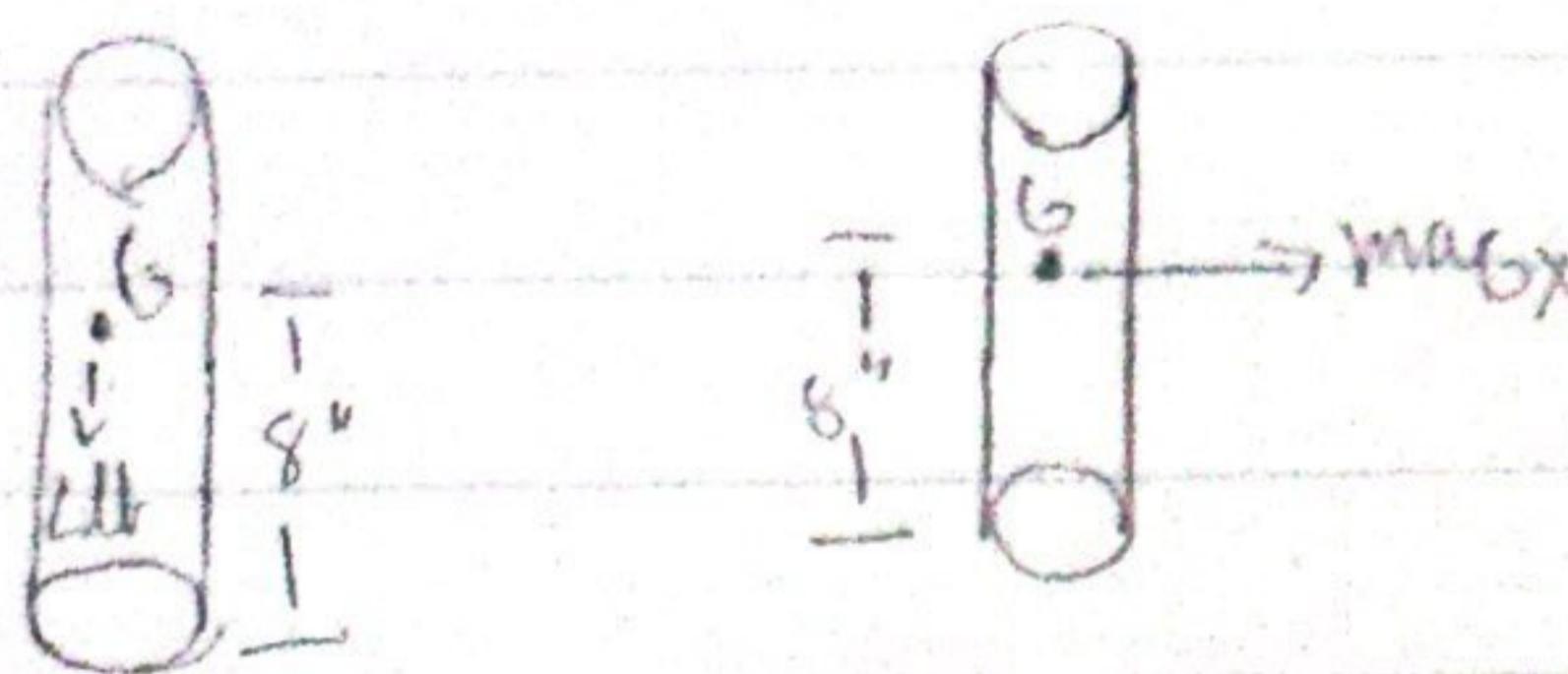
$$a = dr = a = (19.798)(0.15 \text{ m})$$

$$\boxed{a = 2.97 \text{ m/s}^2}$$

Force acceleration I - Problem 1:



FBD = MD



$$\rightarrow \sum F_x = ma_{6x} = 0.0621 a_{6x}$$

$$\uparrow \sum F_y = ma_{6y} = N - 2 = 0$$

$$N = 2 \text{ lb}_z$$

$$F \uparrow \quad N \leftarrow$$

$$\leftarrow \sum M_G = I_{6x} \alpha \Rightarrow \theta F - 2x = 0$$

$$F = \mu_2 N = 0.2(2) = 0.4 \text{ lb}$$

$$\theta F - 2x = 0 \Rightarrow 8(0.4) - 2x = 0 \quad x = 1.6'' > 0.75''$$

assume tipping

$$x = 0.75$$

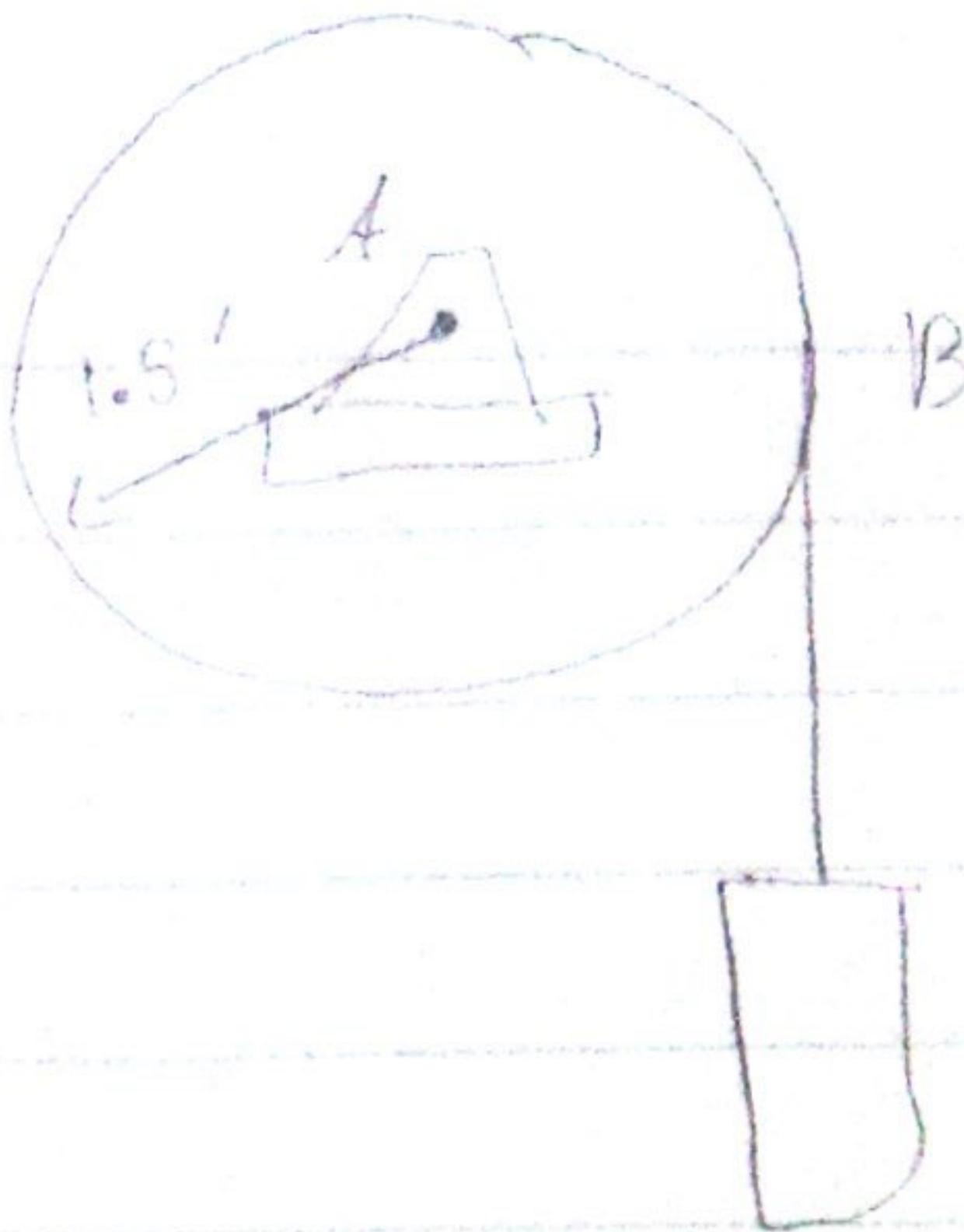
$$\theta F = 2x \quad \theta F = 2(0.75) \quad F = 0.0621 a_{6x}$$

$$F = 0.1875$$

$$0.1875 = 0.0621 a_{6x}$$

$$a_{6\max} = 3.02 \text{ ft/s}^2$$

Force acceleration:



$$m_{drum} \cdot 20lb = \frac{20}{32.2} = 0.6211$$

$$I_6 = 0.8ft \cdot (0.621)(0.8^2) = 0.397$$

$$m_B = 12lb = \frac{12}{32.2} = 0.3726$$

Properties:

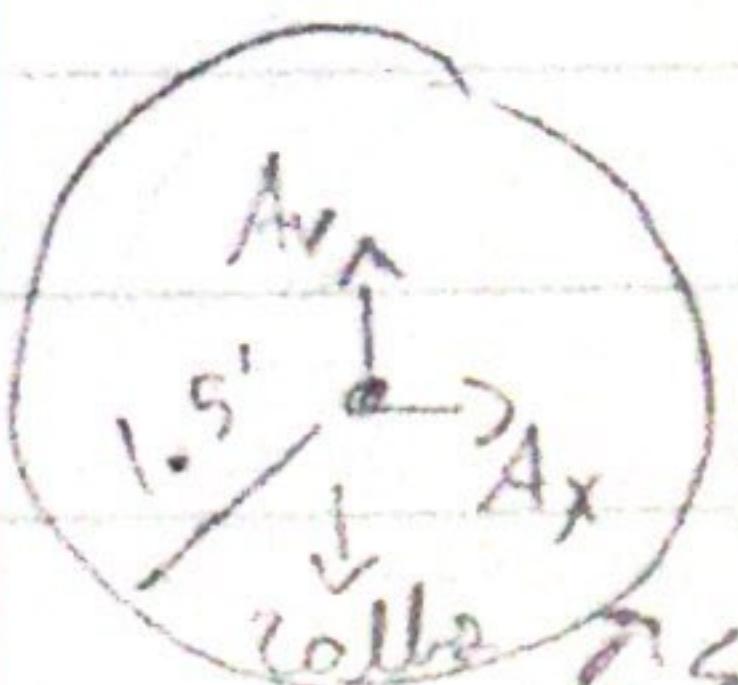
$$I_6 = mR^2$$

$$m_d = \frac{20}{32.2} = 0.621 \quad w_B = 12lb$$

$$w_d = 20lb, \quad R = 0.8ft$$

$$m_B = \frac{12}{32.2} = 0.373$$

FBD Wheel:



$$\sum F_y = Ay = 0$$

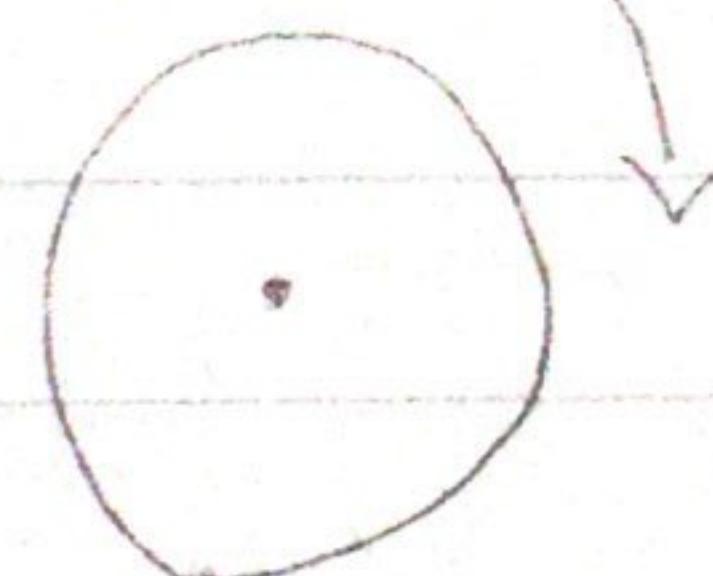
$$\sum F_y = Ay - 20 - T = 0$$

$$\sum M = 1.5T = I_{6a}$$

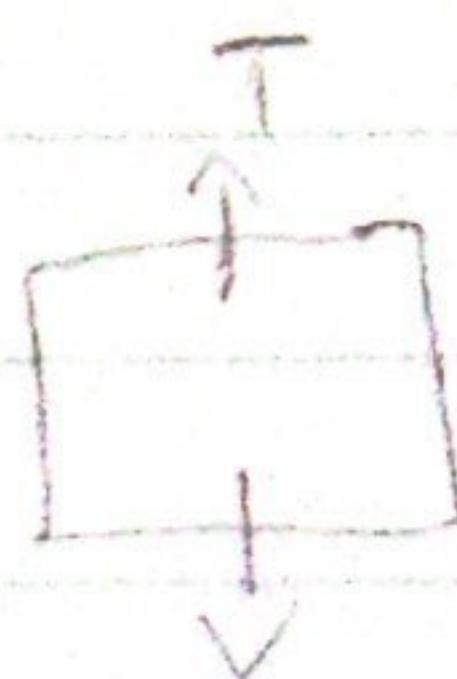
$$Ay - 20 = T \quad 3(1.5)(Ay - 20) = 0.397\alpha \\ 1.5T = 0.397\alpha$$

MD Wheel

$$I_{6a}$$



FBD Block:

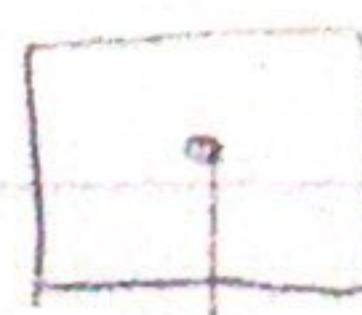


$$\sum F_y = T - 12 = ma_{dy}$$

$$Ay - 20 - 12 = 0.393a_{dx}$$

$$Ay - 8 = 0.373 \times 1.5\alpha$$

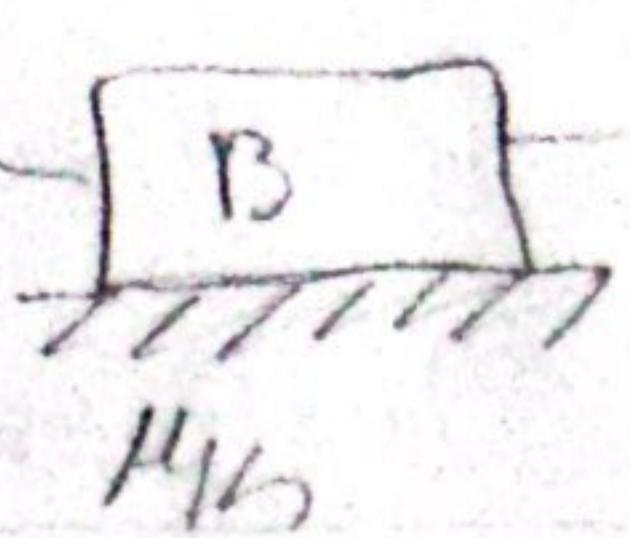
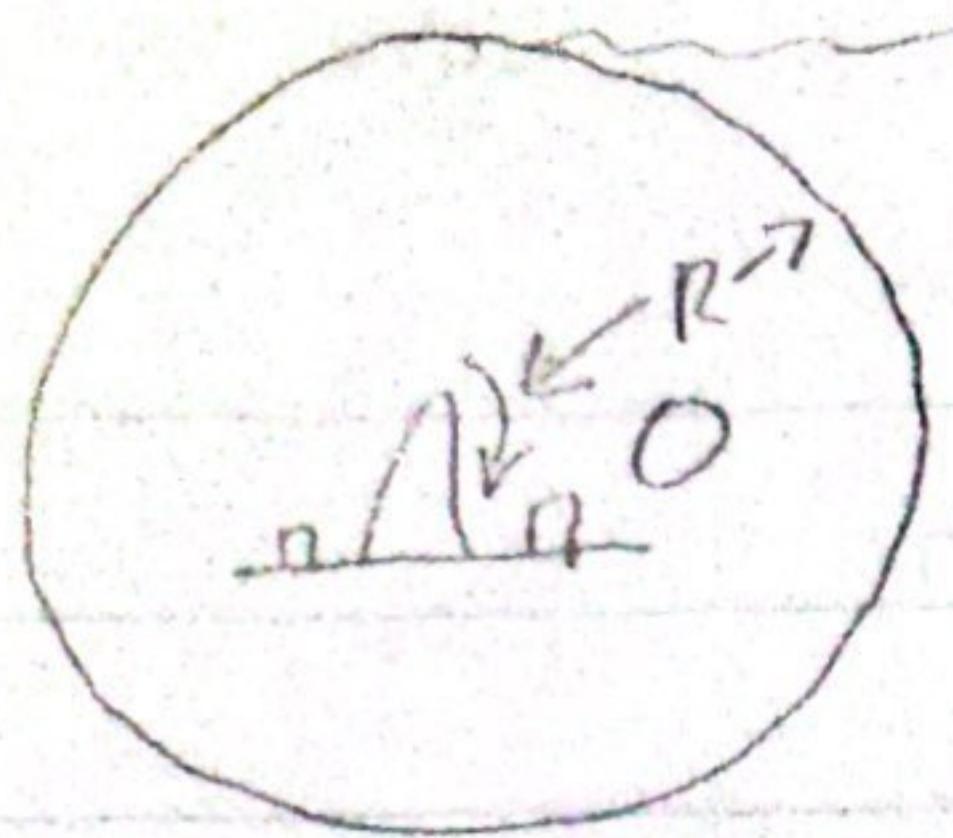
MD Block



$$mg a_{dy}$$

$$Ay - 8 = 0.56\alpha \quad Ay - 14.28 = \alpha$$

$$\frac{Ay - 8}{0.56} = \alpha$$



$m_p = 20 \text{ kg}$
 $R_p = 0.5$
 $m_{\text{rocks}} = 5 \text{ kg}$
 $P = 100 \text{ N}$
 $\mu_k = 0.15$

$$\sum F_x = m_B a \quad P - T - \mu_k m_p g = m_B a$$

$$100 - T - (0.15 \times 5 \times 9.81) = 5a$$

$$100 - T - 7.3575 = 5a$$

$$92.6425 - T = 5a \text{ eqn 1}$$

$$\sum M_O = I_O \alpha$$

$$TR = I_O \alpha$$

$$I_O = \frac{1}{2} m_p R^2$$

$$T(0.5) = (\frac{1}{2} \times 20 \times (0.5)^2) \alpha = 0.5T = (2.5)\alpha \quad T = 5\alpha$$

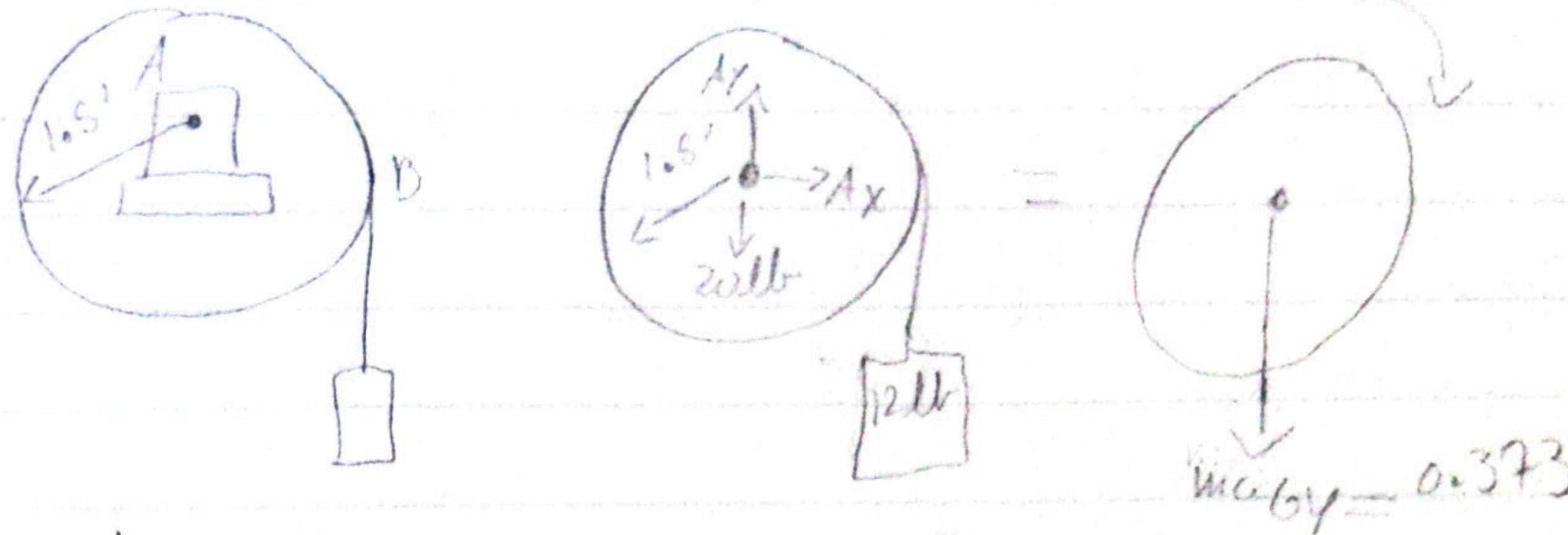
$$T = 5 \left(\frac{a}{0.5} \right) = 10a = T \text{ eqn 2}$$

$$92.6425 - 10a = 5a \quad 92.6425 = 15a \quad a = \frac{92.6425}{15} = \boxed{6.175 \text{ m/s}^2}$$

$$T = 10a = 10(6.175) = \boxed{61.76 \text{ N}}$$

Force acceleration I: Problem 3

$$FBD = MD \cdot I_{Gx}$$



$$\omega_0 = 20 \text{ rad/s}$$

$$F = 12 \text{ lb} \quad \frac{12 \text{ lb}}{32.2} = M_B (32.2)$$

$$M_B = 0.373$$

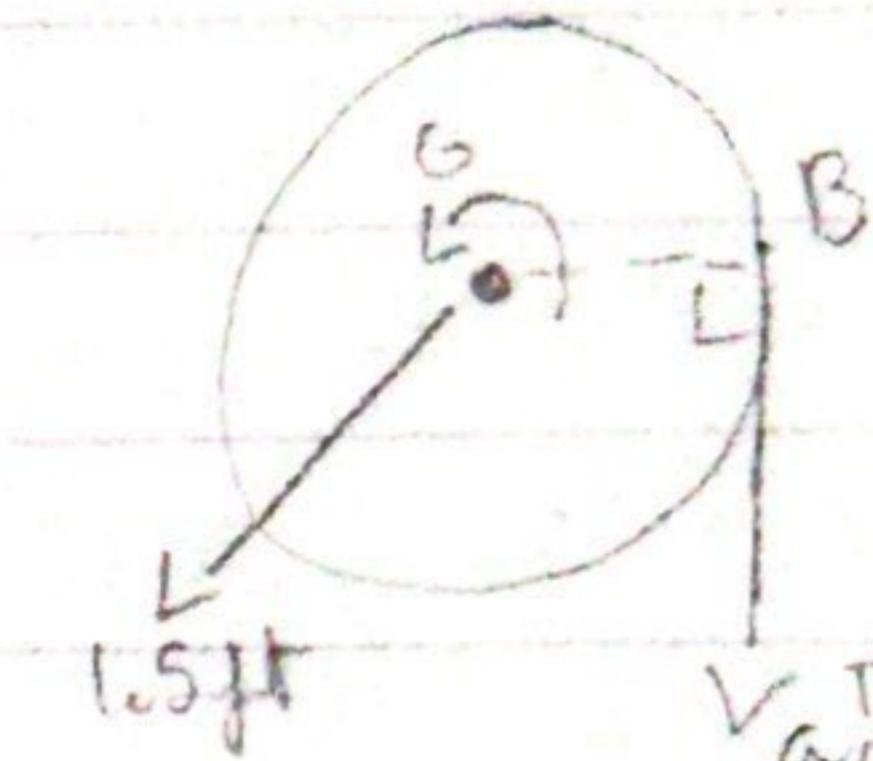
$$F = ma$$

$$M_B = 0.373$$

$$MD = \frac{20}{32.2} = 0.621$$

$$I_G = mR^2$$

$$I_G = (0.621)(0.8)^2 = 0.39744$$



$$\Rightarrow \sum F_x = m a_{Gx} \quad \sum M_g = I_{Gx} = 1.5 T = -0.397 \alpha$$

$$a_x = 0$$

$$\sum F_y = M_B a_{Gy}$$

$$a_G = \alpha r_B / R$$

$$\sum F_y = m a_{Gy}$$

$$T - 12 = 0.373 G_y$$

$$a_y - 20 - T = 0$$

$$a_B = 1.5 d \quad a_B = a_{Gy}$$

$$T - 12 = -(0.373) G_y$$

$$a_{Gy} = 1.5 \alpha$$

$$a_T = \alpha r \quad a_{\text{block}} = a_B = a_{Gy} = 1.5 \alpha$$

$$T - 12 = -(0.373)(1.5 \alpha) \quad T + 0.56 \alpha = 12$$

$$a_y - 20 - T = 0 \quad \Rightarrow -T + a_y = 20$$

$$1.5 T = 0.397 \alpha$$

$$1.5 T - 0.397 \alpha = 0$$

$$\begin{bmatrix} 1 & 0.56 & 6 \\ -1 & 0 & 1 \\ 1.5 & 0.397 & 0 \end{bmatrix} \begin{Bmatrix} T \\ \alpha \\ a_y \end{Bmatrix} = \begin{Bmatrix} 12 \\ 20 \\ 0 \end{Bmatrix}$$

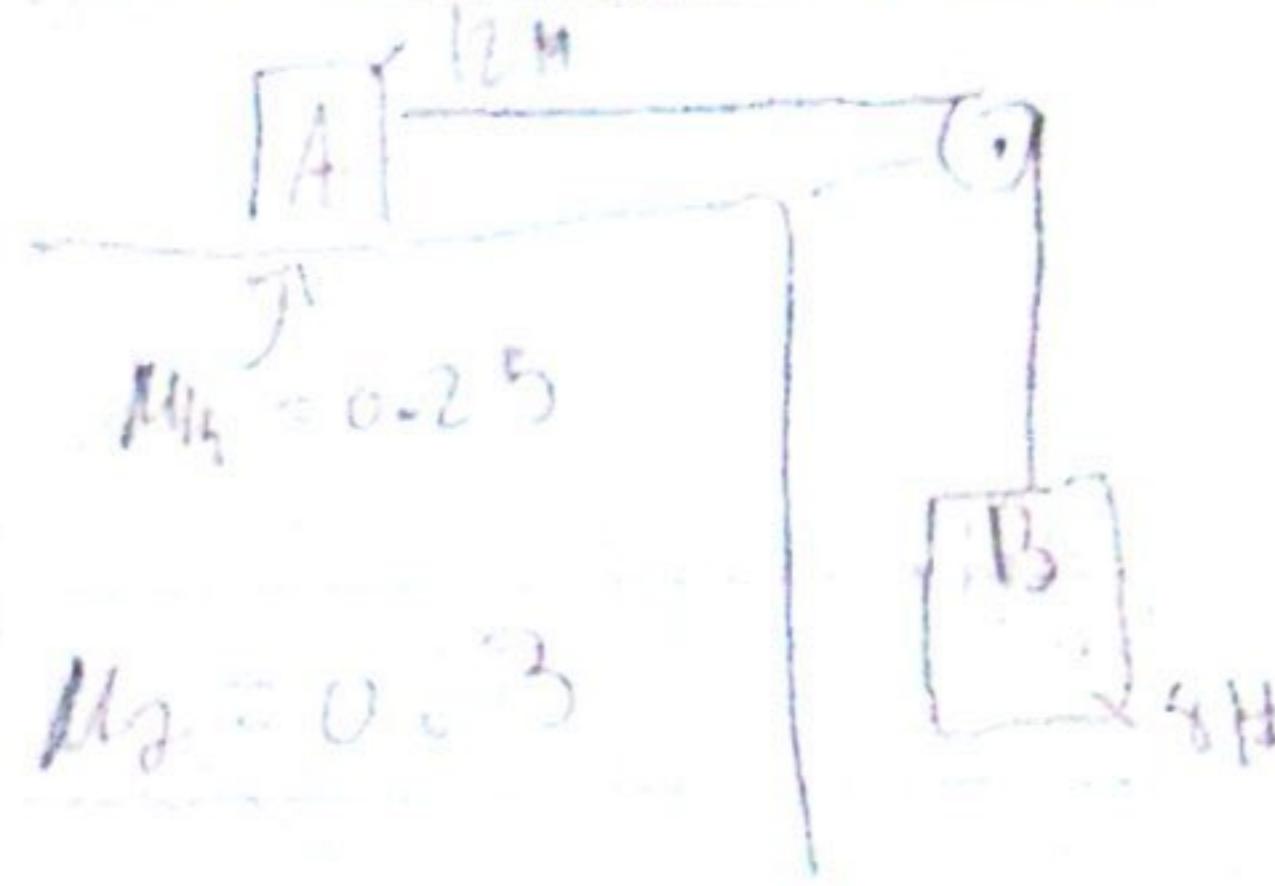
$$T = 3.85 \text{ lbs} \quad \alpha = 14.55 \text{ rad/s}^2 \quad a_y = 23.85 \text{ ft/s}^2$$

$$\sum M_G = I_{Gx} \alpha$$

$$1.5(12) = -0.397 \alpha$$

$$\alpha = 45.3 \text{ rad/s}^2$$

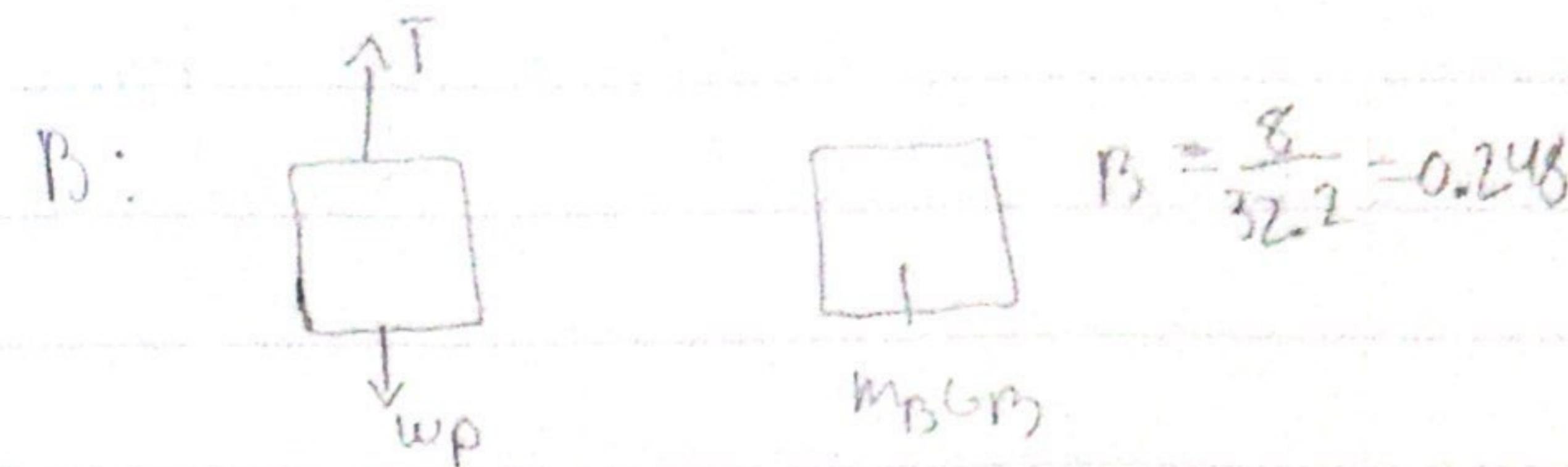
Force acceleration:



$$FBD \Rightarrow 14D$$



$$a = \frac{12}{32.2} = 0.373$$



$$B = \frac{8}{32.2} = 0.248$$

$$A: \sum X \Rightarrow T - F_F = m_A a \quad (1)$$

$$B: \sum X \Rightarrow 0$$

$$\sum Y \Rightarrow N_A - W_A = 0$$

$$\sum Y \Rightarrow T - 8\# = m_B a_B$$

$$F_F = \mu N_A = 0.25(12)$$

$$\frac{T-8}{-0.248} = a \quad (2)$$

$$F_F = 3\#$$

$$\sum X \Rightarrow T - F_F = m_A a \quad T - 3 = 0.373 \left(\frac{T-8}{-0.248} \right) \frac{0.373}{-0.248} \equiv 1.504(T-8)$$

$$T - 3 = 1.504T + 12.03$$

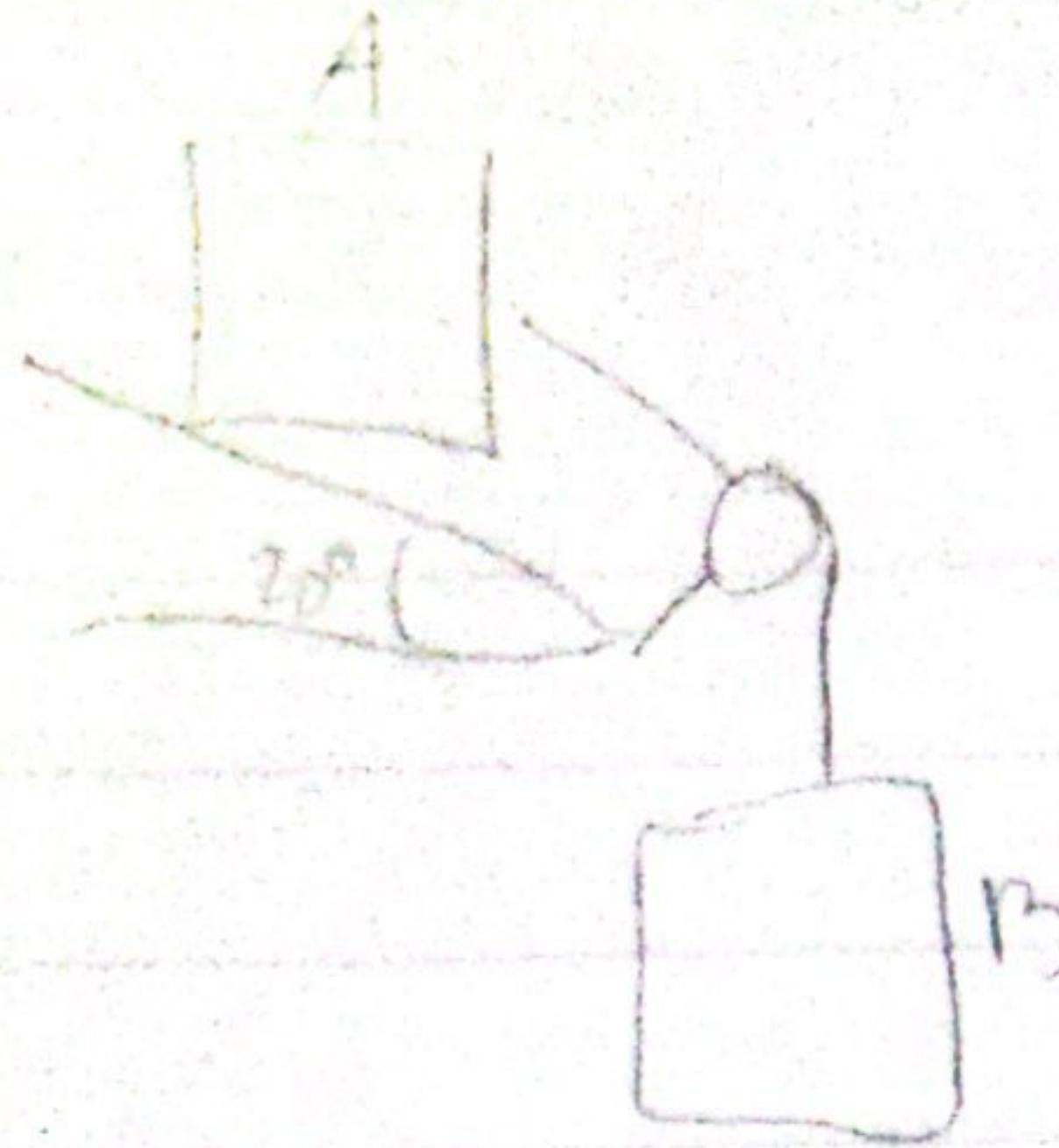
$$1.504T - 1.504 \times 8$$

$$2.504T = 15.03$$

$$1.504T - 12.032$$

$$T = 6\#$$

Force acceleration:



Classify motion:

Blocks A & B: Translation

Properties:

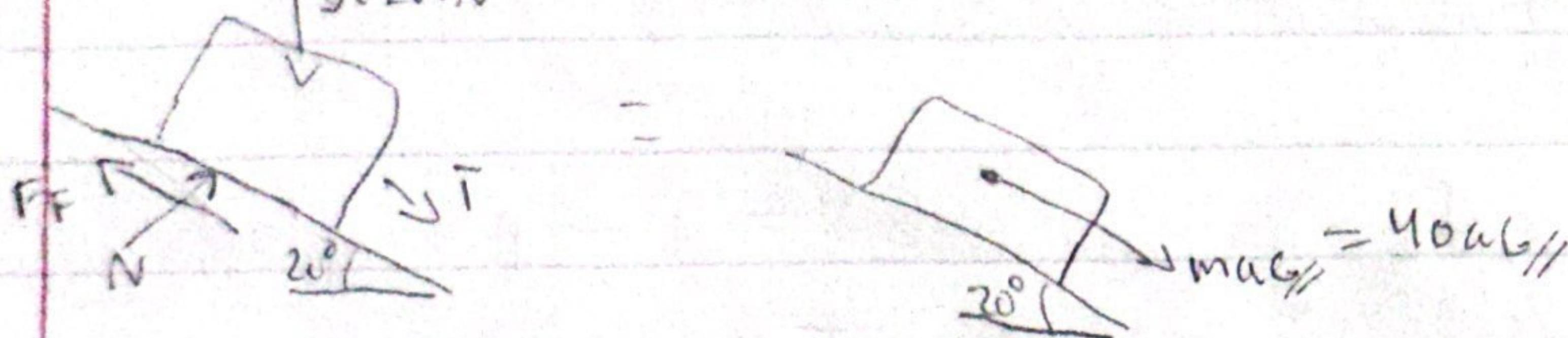
$$m_A = 40 \text{ kg} \quad W_A = 40(9.8) = 392.4 \text{ N}$$

$$m_B = 30 \text{ kg} \quad W_B = 30(9.8) = 294.3 \text{ N}$$

$$\mu_s = 0.2 \quad \mu_k = 0.15$$

$$FBD = \text{FD}$$

$$392.4 \text{ N}$$



$$A: \quad F_F = \mu_k N = 0.15(369) = 55.4 \text{ N}$$

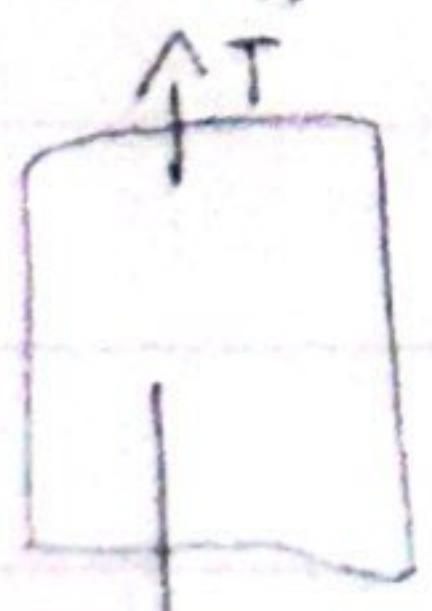
$$\sum \text{EF}_\perp = m_A g_\perp = N - 392.4 \cos 20^\circ = \phi = N = 369 \text{ N}$$

$$\sum \text{EF}_\parallel = m_A g_\parallel \Rightarrow T - F_F + 392.4 \sin 20^\circ = 40 a_{6//}$$

$$T - 55.4 \text{ N} + 392.4 \sin 20^\circ = 40 a_{6//}$$

$$(1): T - 40 a_{6//} = -78.86$$

$$FBD = \text{FD}$$



$$294.3 \text{ N}$$

$$(2) \downarrow \sum F_y = m_B a_y \Rightarrow 294.3 - T = 30 a_y$$

$$\text{Kinematic: } a_{6//} = a_y$$

$$(1) T - 40 a_{6//} = -78.86$$

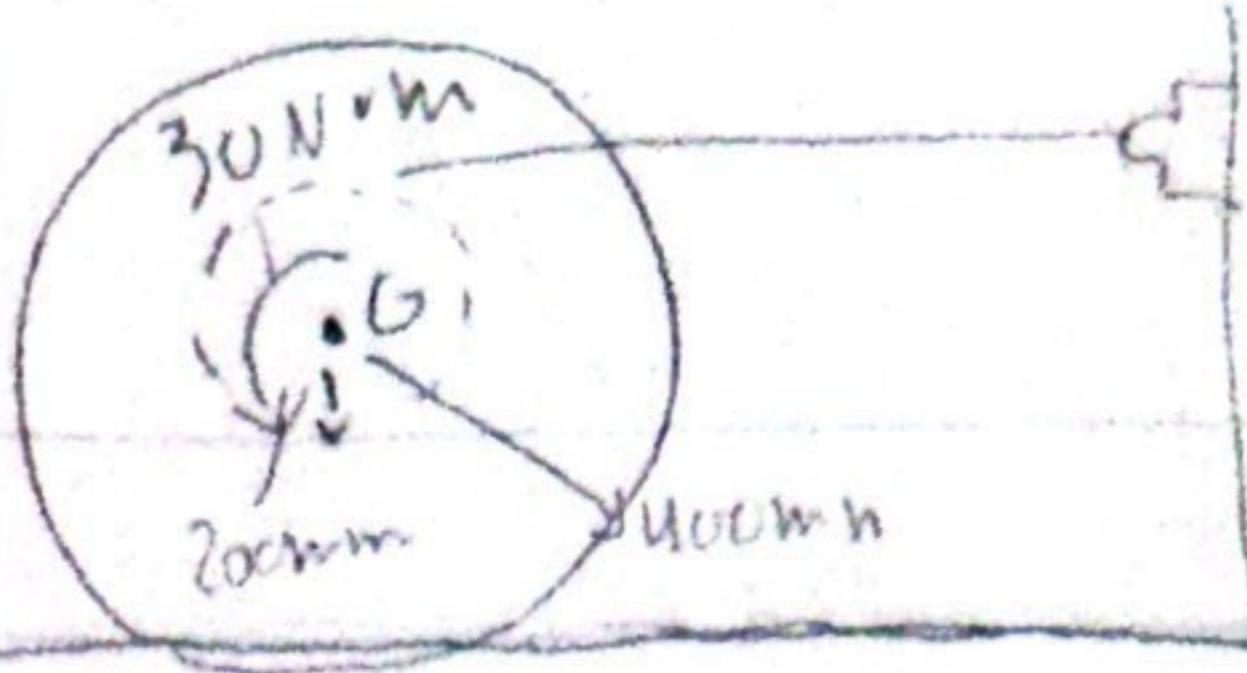
$$(2) T + 30 a_{6//} = 294.3$$

$$\boxed{T = 134 \text{ N} \quad a_{6//} = 5.32}$$

Force acceleration:

$$M=20\text{ kg} \quad r_{oj}=250\text{ mm} \quad \mu_D = 0.1$$

$$C=30\text{ nm}$$



Classify motion

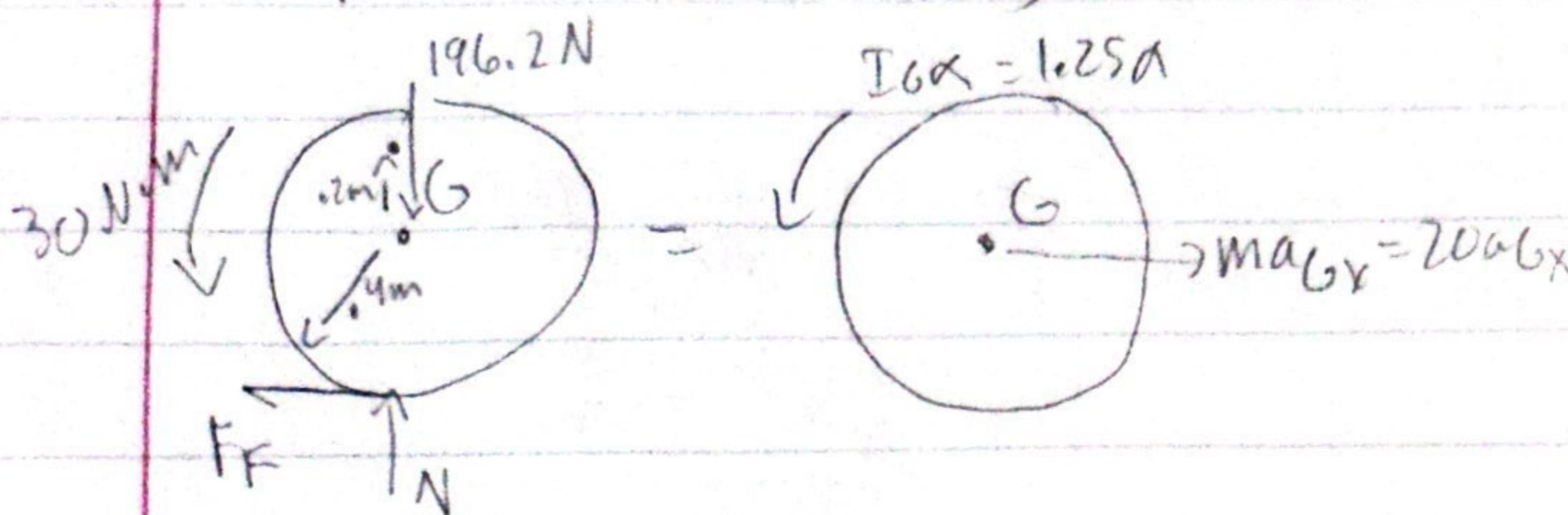
6pm

Properties

$$m=20\text{ kg} \quad W=20(9.81)=196.2\text{ N}$$

$$I_G = m r_0^2 = 20(0.25)^2 = 1.25\text{ kg}\cdot\text{m}^2$$

FBD = ID



$$\uparrow \sum F_y = ma_{Gy} \Rightarrow N - 196.2 = 0 \Rightarrow N = 196.2$$

$$\rightarrow \sum F_x = ma_{Gx} \Rightarrow T - F_F = 20a_{Gx} \quad (1)$$

$$\sum M_G = I_G \alpha \Rightarrow 30 - F_F(0.4) - T(0.2) = 1.25 \alpha$$

$$\text{2 Eqn 4 unknowns must solve } F_F = \mu m N = 0.1(196.2) = \boxed{F_F = 19.26\text{ N}}$$

$$a_{Gx} = \alpha r \quad a_{Gy} = \alpha r = 0.2 \alpha$$

$$(1): T - 19.26 = 20(0.2 \alpha)$$

$$T - 19.26 = 4\alpha \Rightarrow T = 19.26 + 4\alpha$$

$$(2): 30 - 19.26(0.4) - T(0.2) = 1.25 \alpha$$

$$30 - 7.68 - 0.2T = 1.25 \alpha \Rightarrow 22.32 - 0.2(19.26 + 4\alpha) = 1.25 \alpha$$

$$T = 55.21 \quad \frac{d}{r} = 8.89$$

$$22.32 - 3.852 - 0.8\alpha = 1.25\alpha \Rightarrow 18.468 = 2.05\alpha$$

$$\alpha = \frac{18.468}{2.05} = 9.0088$$

$$T = 19.26 + 4(9.0088) = 55.2951$$