$$a_G = \alpha \, r_{M/G}$$

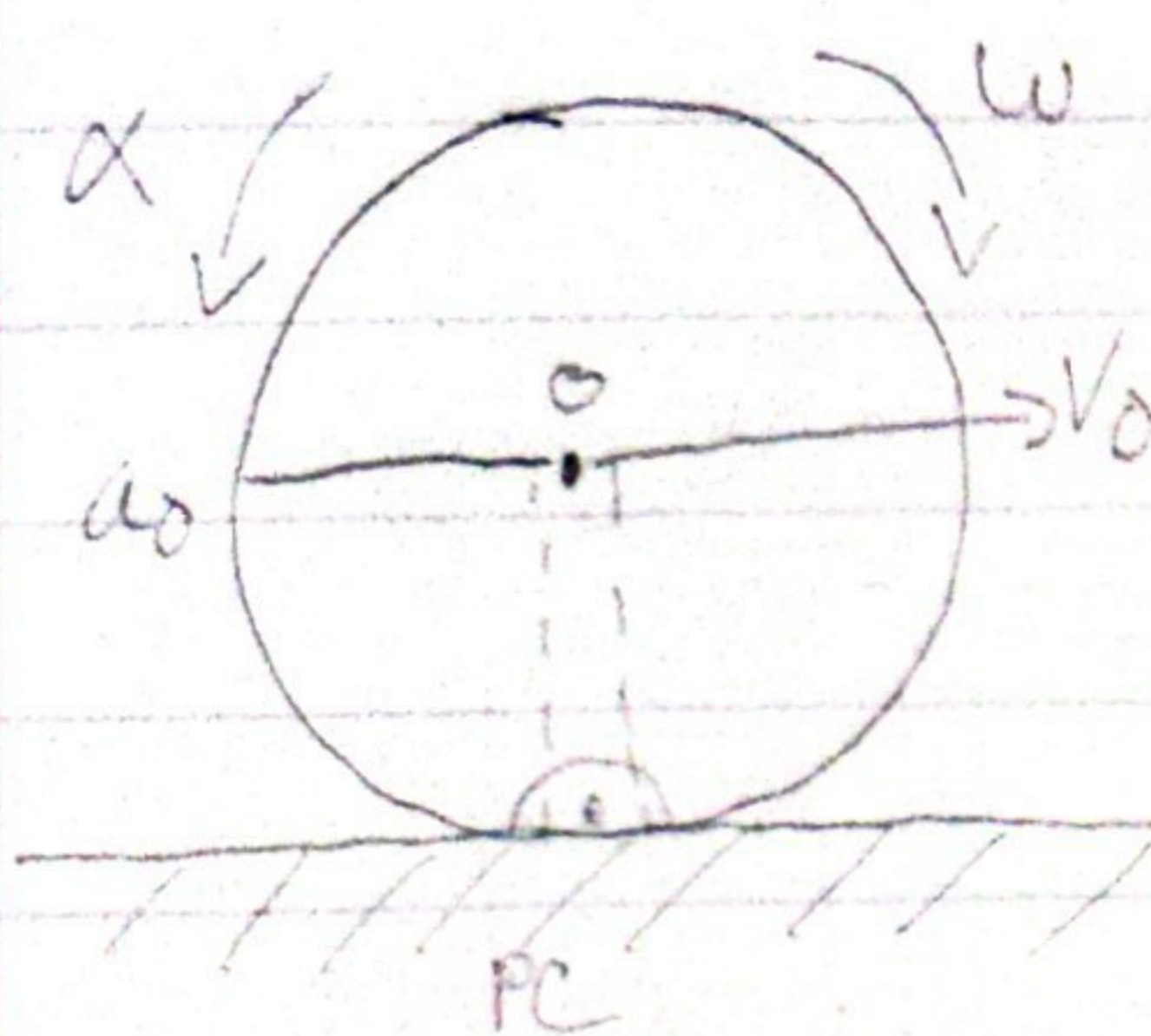$$a_B^T = \alpha \, r_{B/G}$$

Kinematic Relation

$$a_B = 1.5\alpha \qquad a_B = a_{Gy}$$
$$a_{Gy} = 1.5\alpha$$
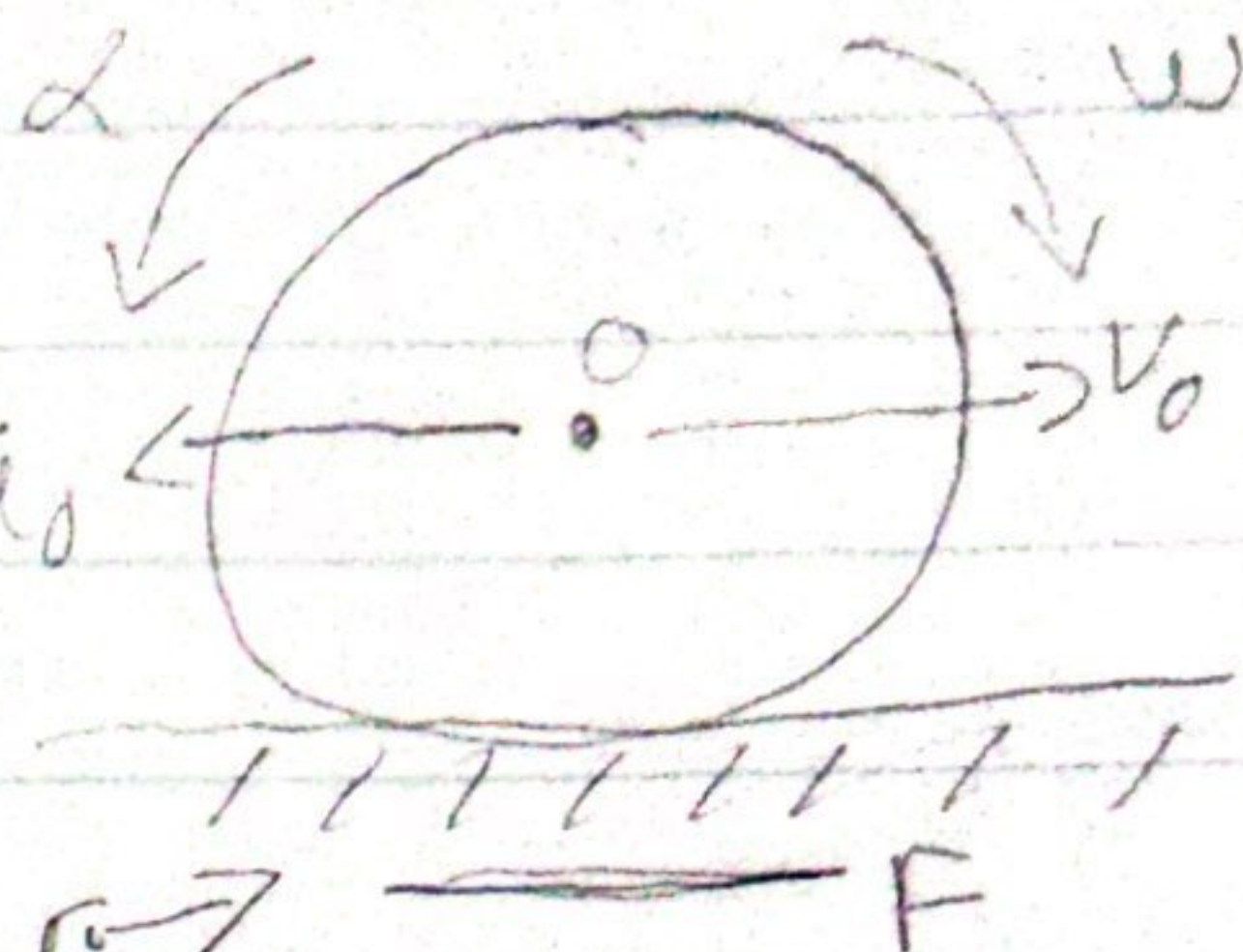
1.5 ft

No slip: Kinematic   **slipping:**

* assume no slip first

* solve for friction force

opposes motion of P.C. solve $a_0 \neq \alpha r$
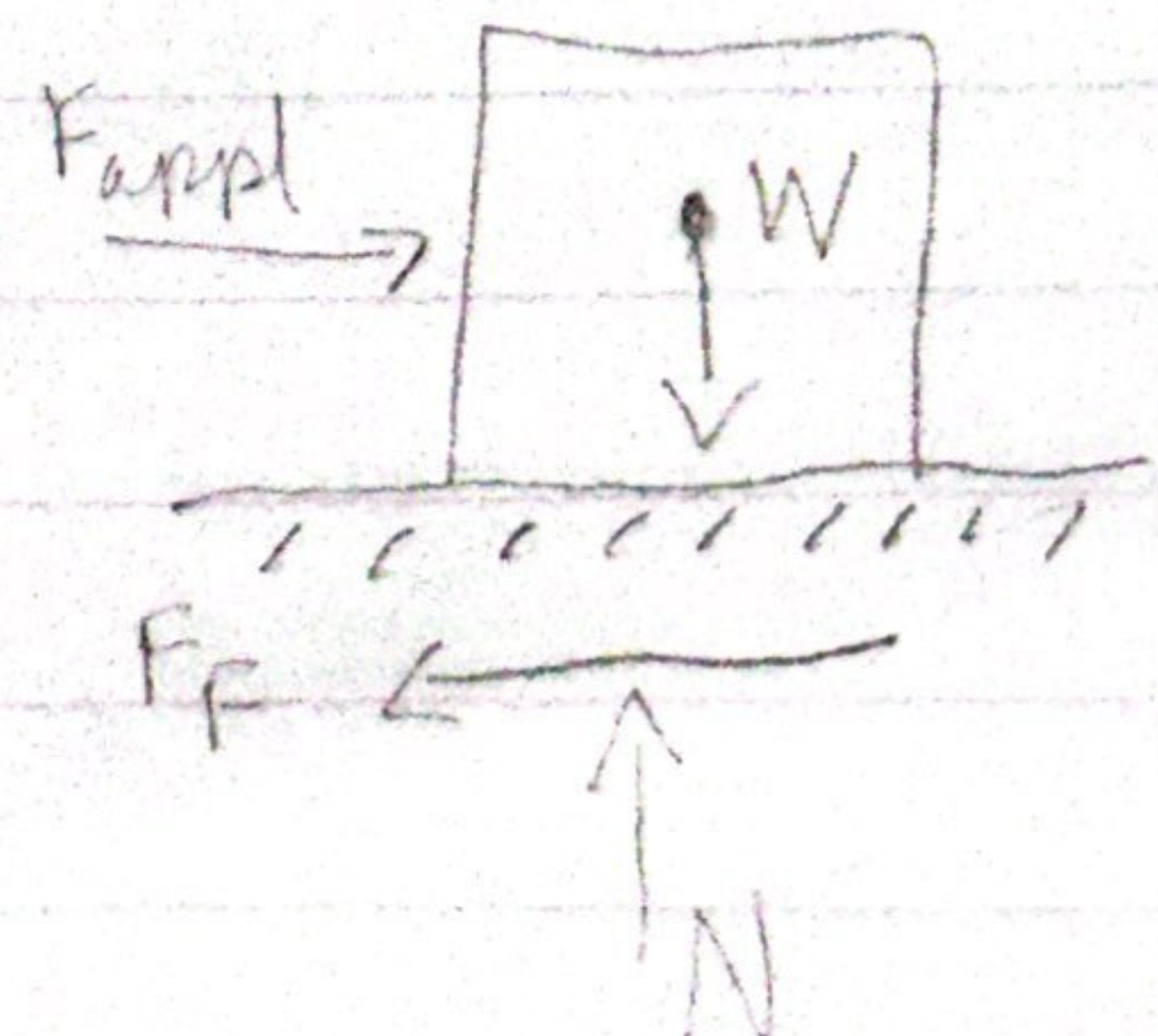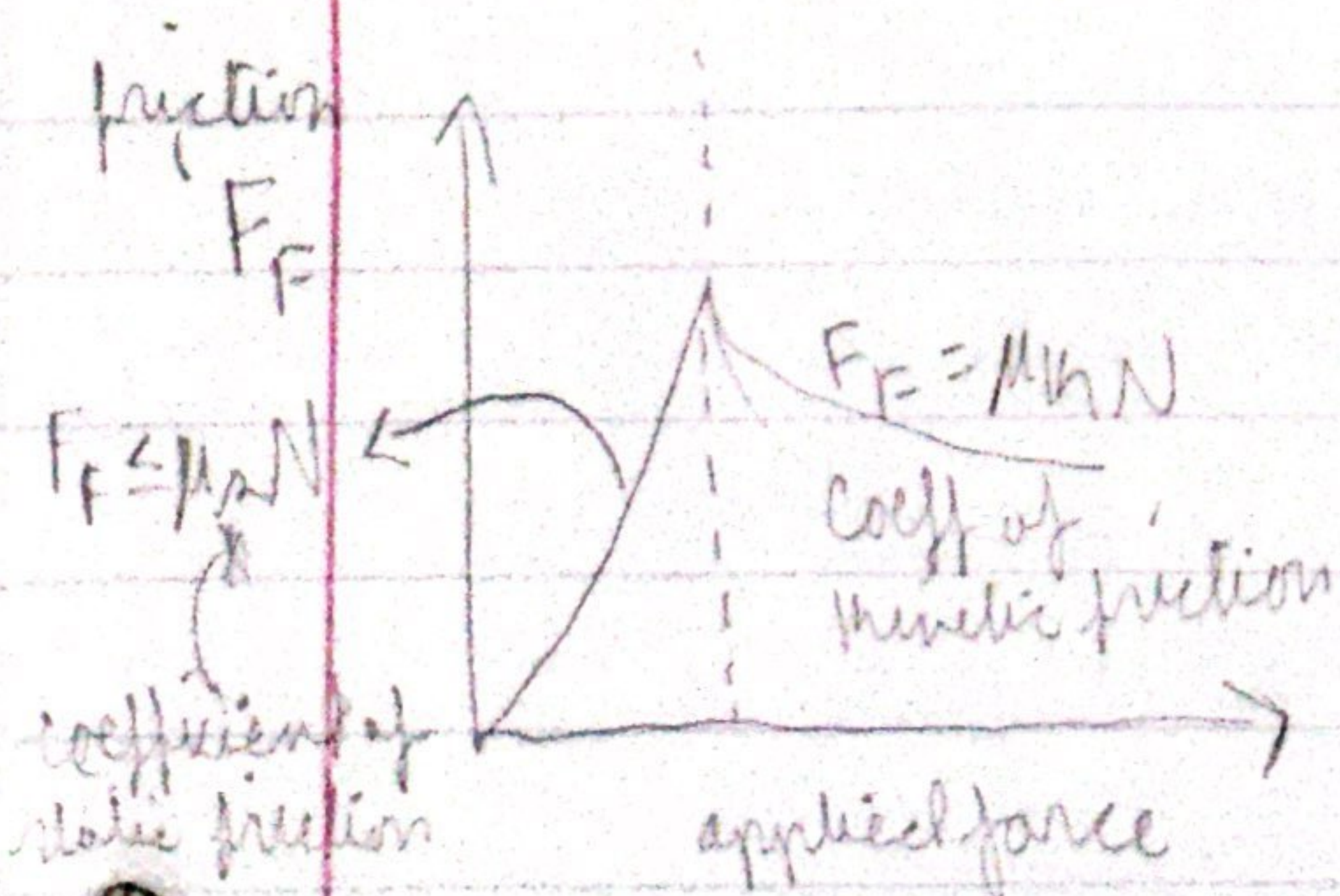
$(v_0 \neq wr)$, two objects move over each other

$F_F = \mu_k N$

if no, then use this

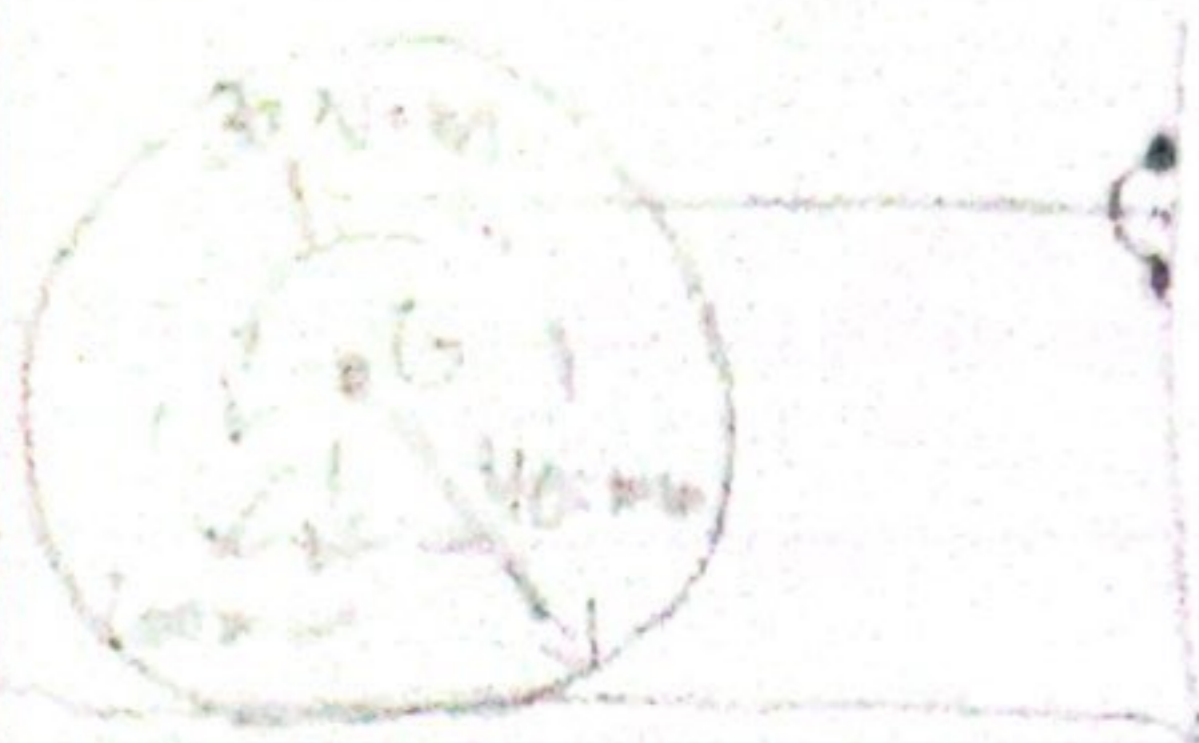√ * $a_0 = \alpha r$

$v_0 = wr$

solve $F \leq \mu_s N$ if yes use this

friction F_F

$F_F = \mu_k N$
Coeff of kinetic friction

$F \leq \mu_s N$

coefficient of static friction

applied force

F_{appl} → W

F_F ← ↑ N

Force acceleration II: problem 8

$F_F = \mu_k N$ ← two objects moving over each other
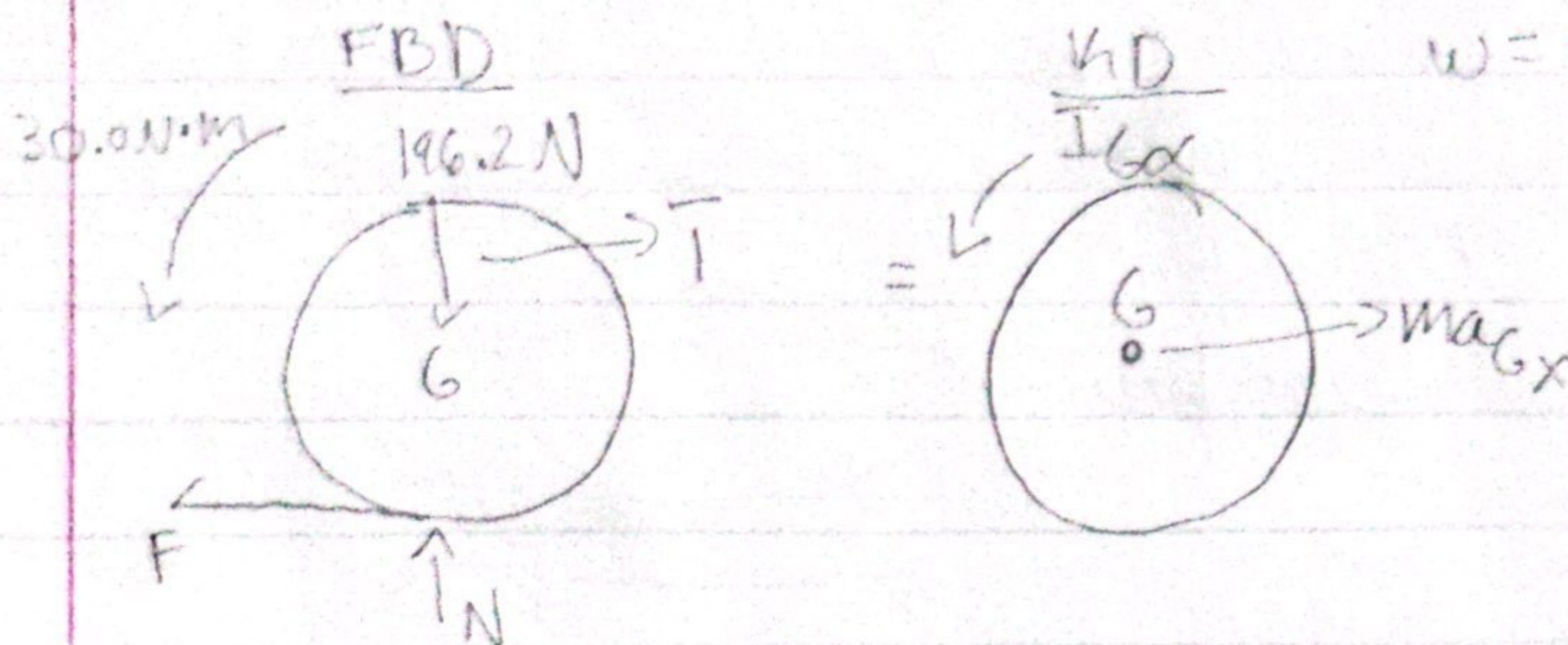
* make an assumption to start the problem, always assume no slip

Radius of gyration $k = 0.25m$

$\hookrightarrow I_G = mk^2$

Classify motion:

$m = 20kg$

$I_G = mk^2 = (20)(0.25)^2 = 1.25$

$W = mg = (20)(9.81) = 196.2$

30.0 N·m

FBD

196.2 N

$= $

KD

$I_G \alpha$

$\Rightarrow \Sigma F_x : -F + T = Ma_{Gx} = 20\, a_{Gx}$

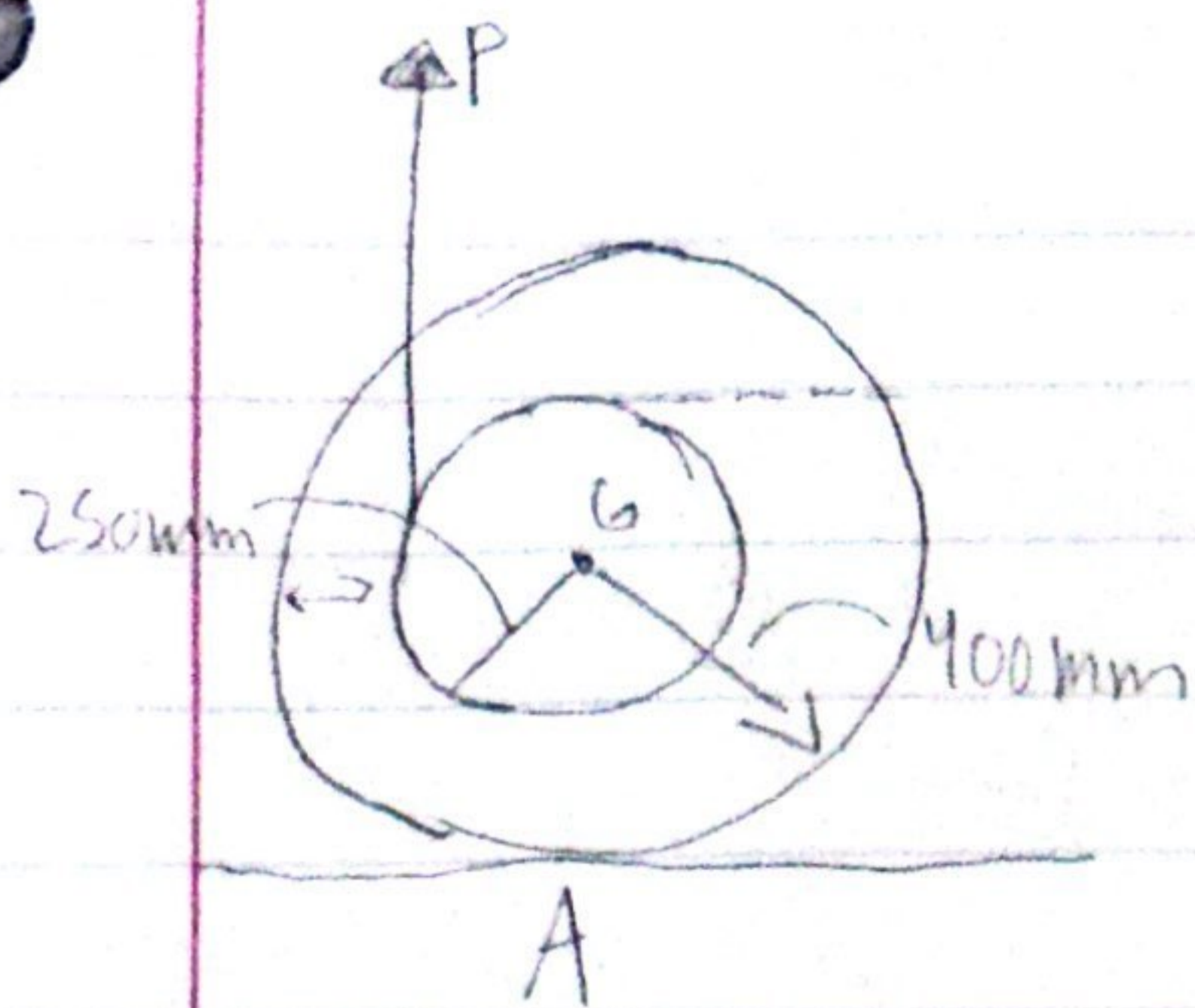must be slipping $\therefore F = \mu_k N = 0.1(196.2) = 19.62 N$
at ground

Statics:

$\xrightarrow{+} \Sigma F_x = 0$

$\uparrow \Sigma F_y = 0$

$\Sigma M_G = 0$

Dynamics:

$\xrightarrow{+} \Sigma F_x = Ma_{Gx}$

$\uparrow \Sigma F_y = Ma_{Gy}$

$\Sigma M_G = I_G \alpha$

force acceleration III : problem I

A

$m = 10\,kg$

radius of gyration $k_G = 0.3m$ $d_1 = 0.25m$

$\mu_s = 0.2$ $\mu_m = 0.15$ $P = 50N$ $d_2 = 0.4m$

dpm

$I_G = mk^2 = (10\,kg)(0.3)^2 = 0.9$

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

$a_0 = \alpha r \; (9.81)(0.4) = 3.924$

FBD

kD
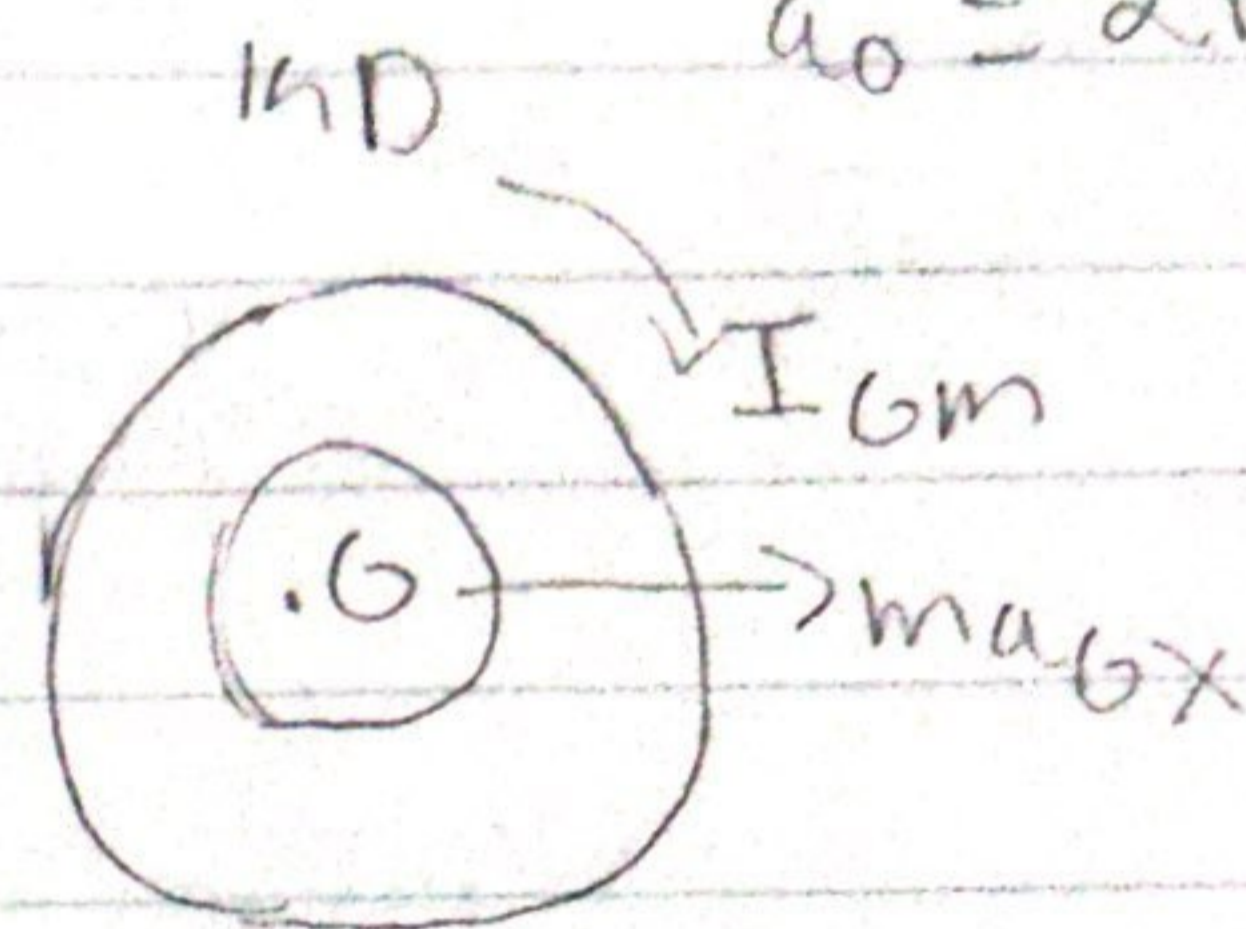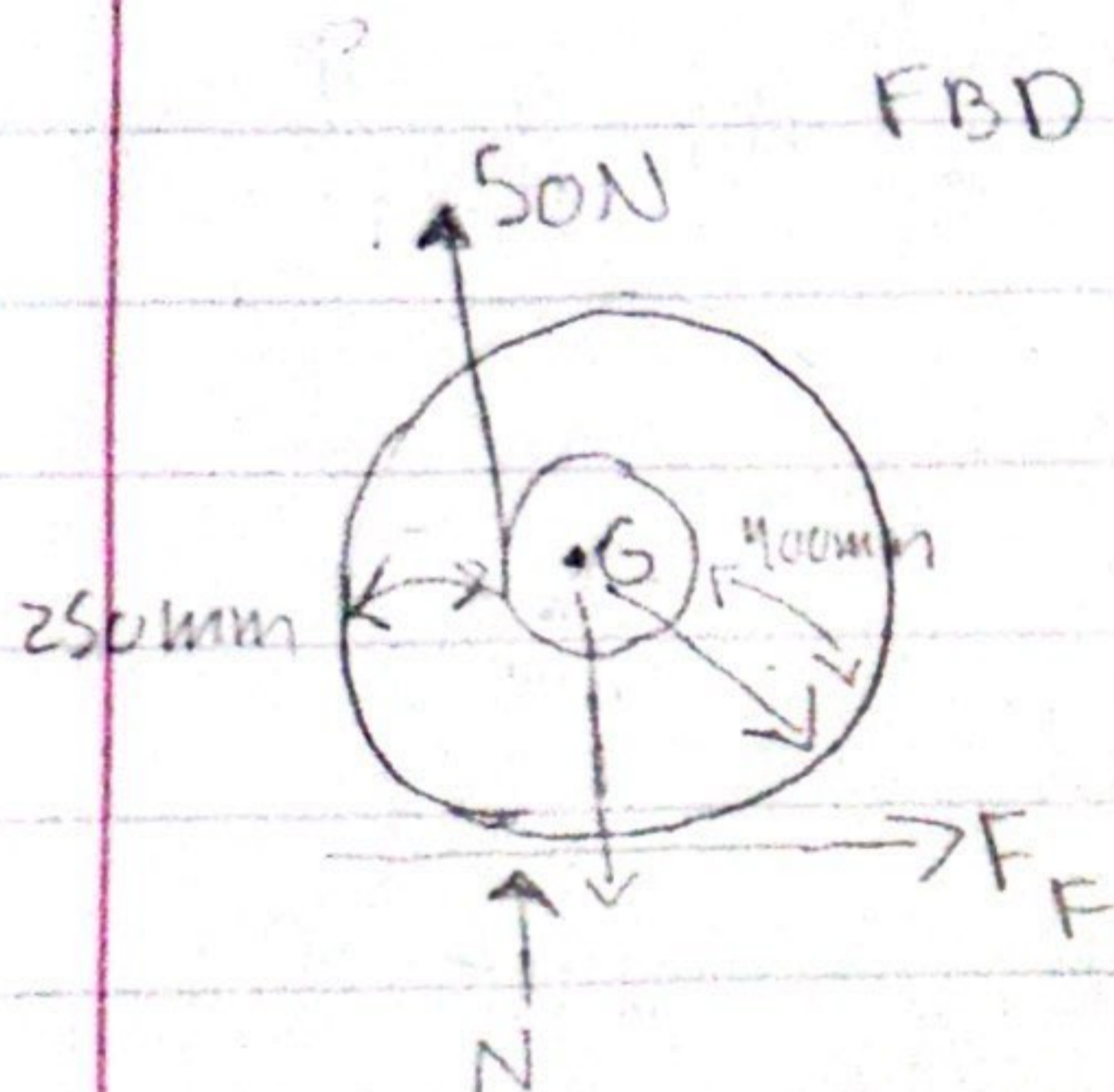
1) $\uparrow \Sigma F_y \Rightarrow$ $50 - 98.1 + N = 0$ $N = 48.1$

2) $\rightarrow \Sigma F_x \Rightarrow$ $F = ma_{Gx} = 10 a_G x = 10(0.4\alpha)$

3) $\circlearrowleft \Sigma M_G \Rightarrow$ $-50(0.25) + F(0.4) = -0.9\alpha$

assume no slip $F = 4\alpha$

$a_{Gx} = \alpha r = 0.4\alpha$ $-50(0.25) + (0.4\alpha)(0.4) = -0.9\alpha$

$\alpha = 5.0 \, rps^2 \,\circlearrowleft$

$a_{Gx} = 0.4\alpha = 2.0 \, m/s^2$ $F = 10 a_{Gx} = 20.0 \, N$
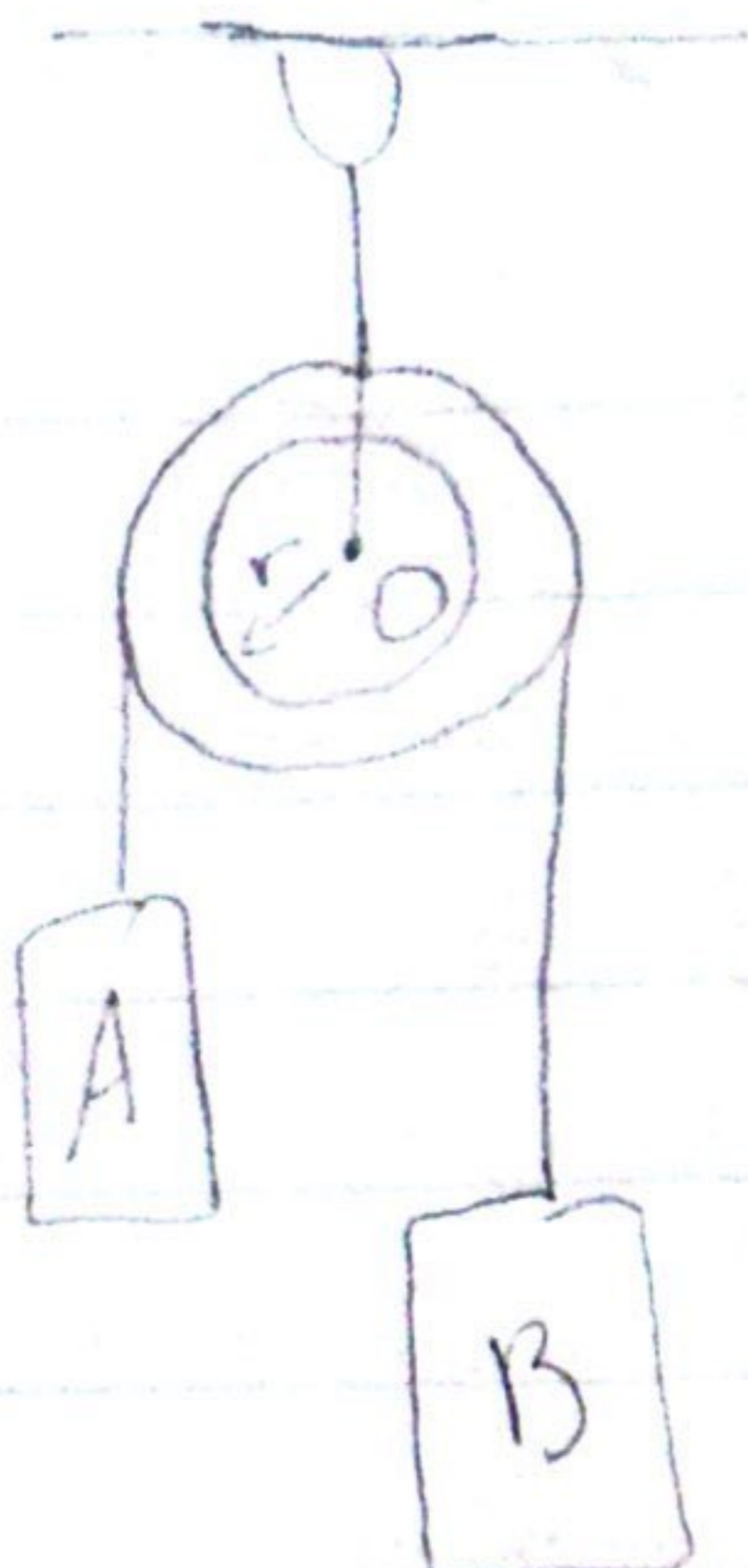
$F_{max} = \mu_s N = 0.2(48.1N) = 9.62 N$

$F > F_{max}$ ∴ slipping

$F = \mu_m N = 0.15(48.1N) = 7.21 N$

$-50(0.25) + F(0.4) = -0.9\alpha$

$-50(0.25) + 7.21(0.4) = -0.9\alpha$
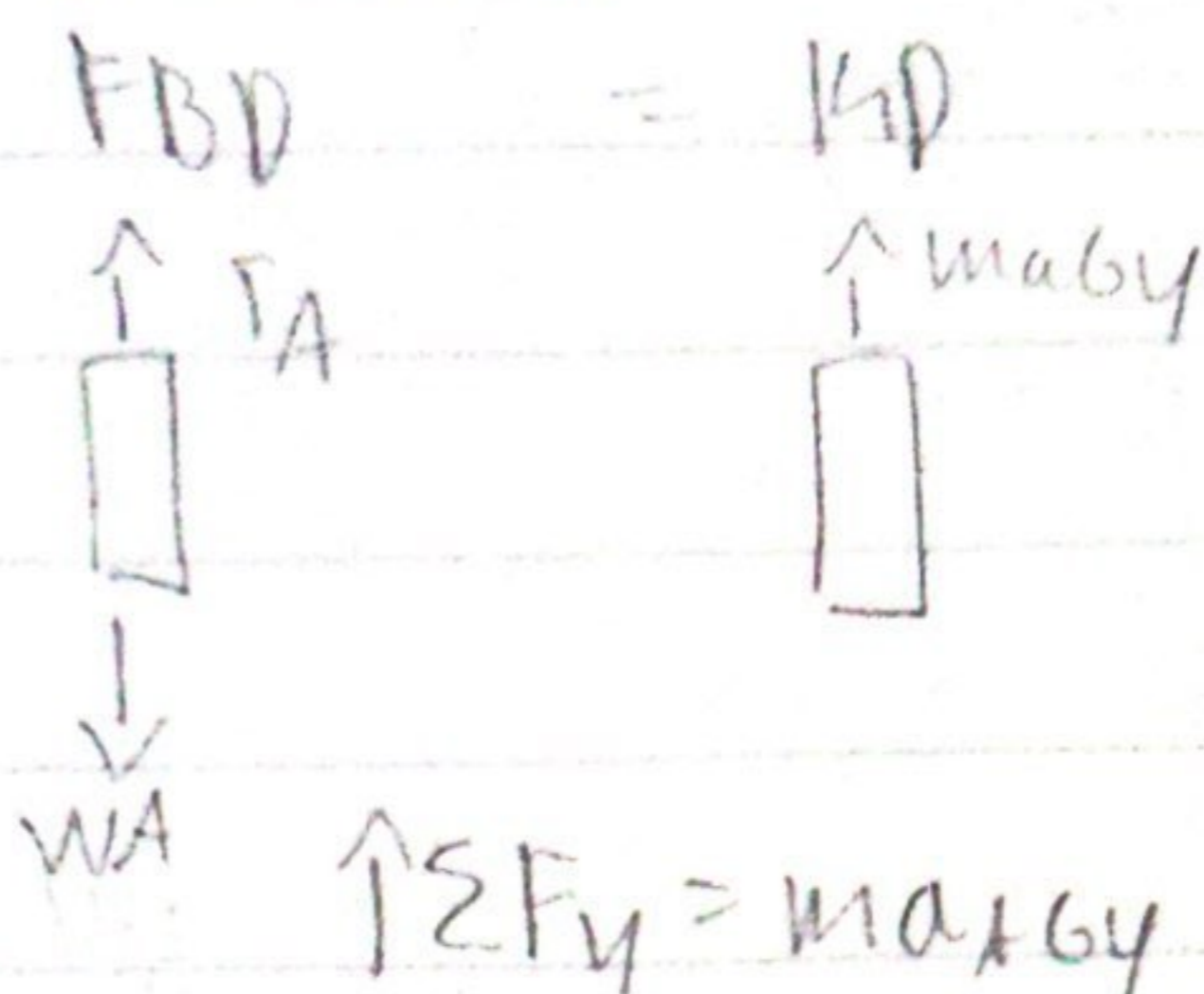
$\boxed{\alpha = 10.68 \, rps^2}$

Force acceleration:

$m_A = 5\,kg$
$m_B = 10\,kg$
$m_{pulley} = 3\,kg$
$r = 0.15\,m$

Block A:

FBD = KD

$\uparrow T_A$ $\uparrow m_A a_{Gy}$

$a = \alpha r$

$\downarrow W_A$

$\uparrow \Sigma F_y = m_A a_{Gy}$

$T_A - W_A = m_A a_{Gy} \quad \alpha r$

$T_A - (5\,kg)(9.81) = 5\,kg\,a\,r$

$T_A - 49 = (5\,kg)(0.15m)\alpha$

① $T_A = 0.75\alpha + 49$

Block B:

FBD   KD

$\uparrow T_B$

$\downarrow W_B$ $\downarrow m_a a_{Gy}$

$\uparrow \Sigma F_y = m_a a_{Gy}$
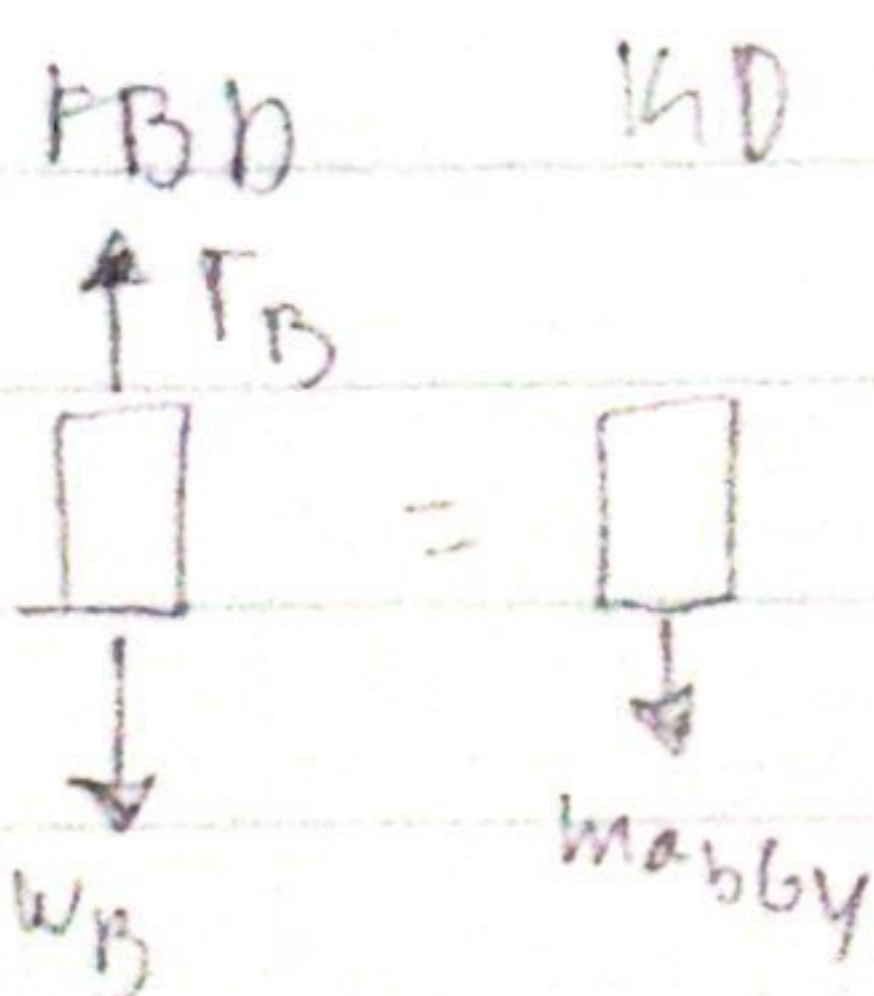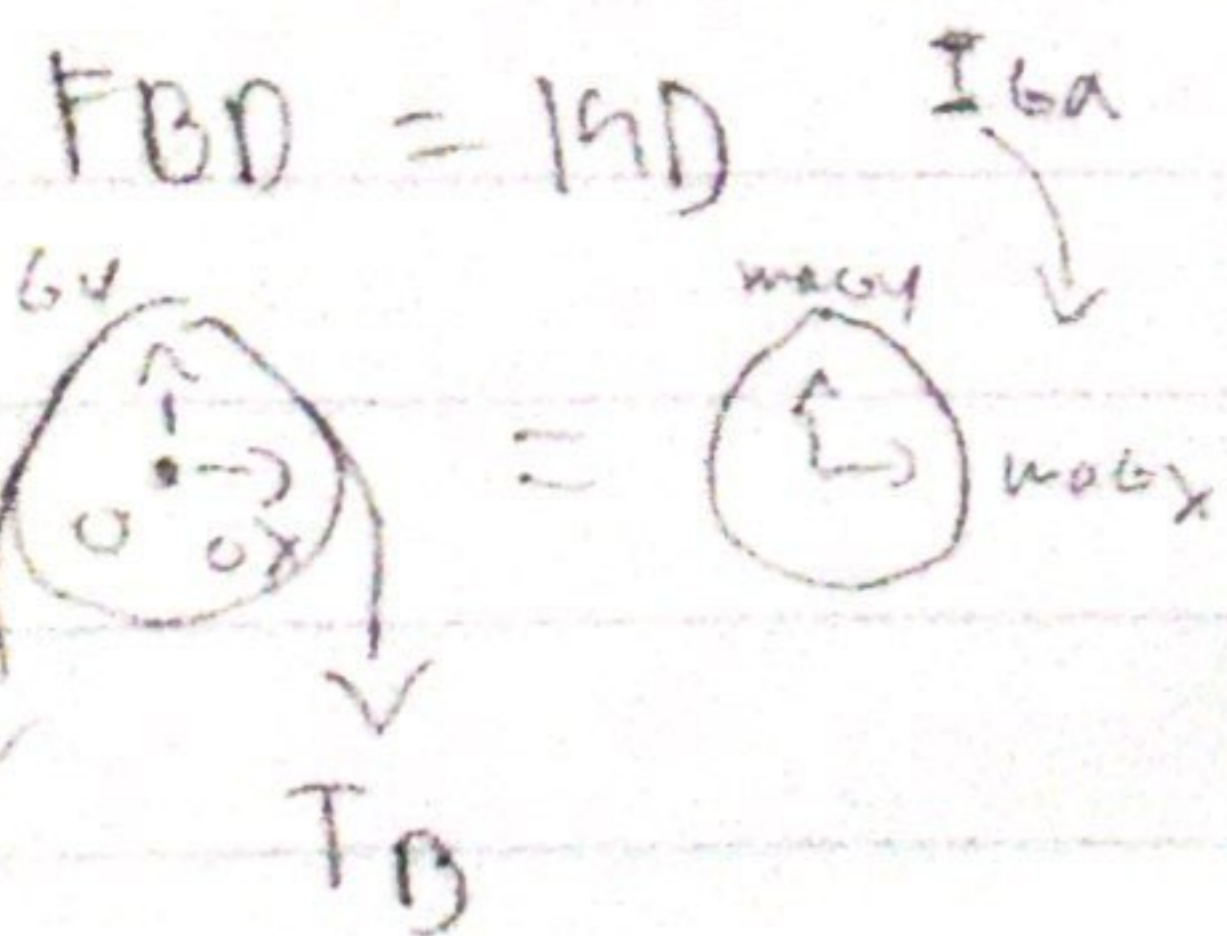
$T_B - W_B = -m_a a_{Gy}$

$T_B - (10\,kg)(9.8) = -(10\,kg)\alpha r$

$T_B - (10)(9.8) = -(10\,kg)\alpha(0.15m)$

$T_B = -1.5\alpha + 98$

$I_0 = \frac{1}{2}m(r^2)$
$\frac{1}{2}(3)(.15)^2$

Drum

FBD = KD $I_G\alpha$

T_B

$\Sigma M_0 = I_0\alpha \quad T_B(.15m) - T_A(0.15m) = I_0\alpha$

$T_B - T_A = \frac{1}{2}(3)(.15)\alpha$

$T_B - T_A = 0.225\alpha$

$T_B - T_A = 0.225\alpha$

$-1.5\alpha + 98 - (0.75\alpha + 49) = 0.225\alpha$
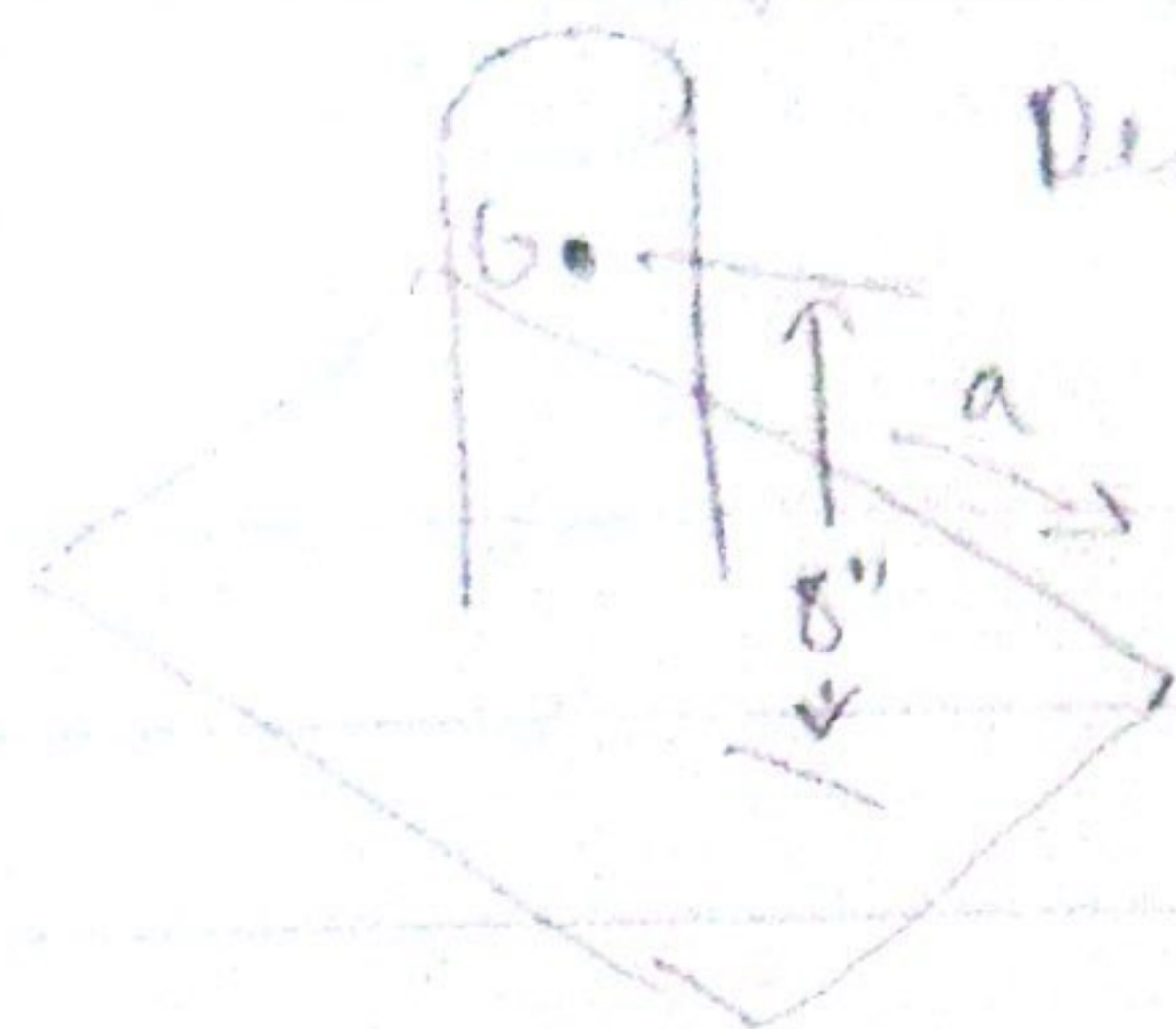
$\boxed{\alpha = 19.798}$ $a = \alpha r = a = (19.798)(0.15m)$

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

Force acceleration I - Problem II:

Diameter = 1.5" $\mu = 0.2$

$m = \dfrac{2lb}{g} = 0.0621 = \dfrac{2}{9.81}$

FBD = KD
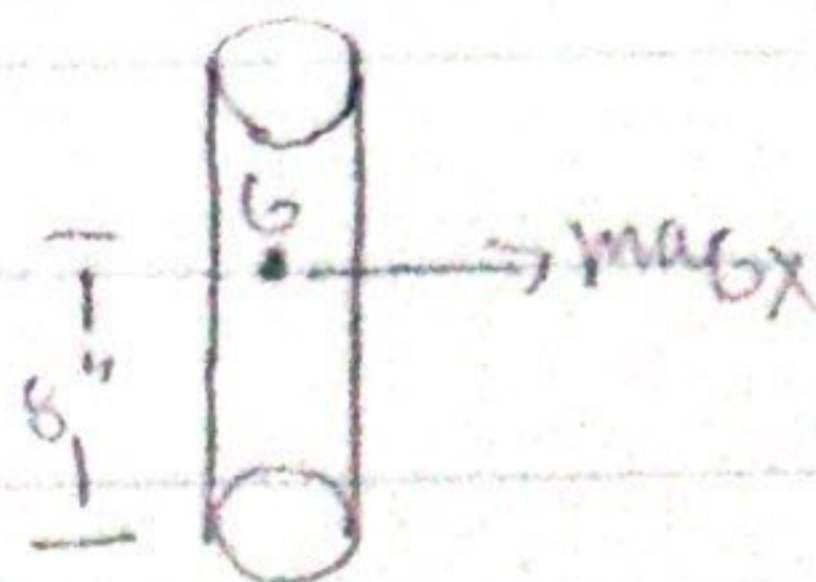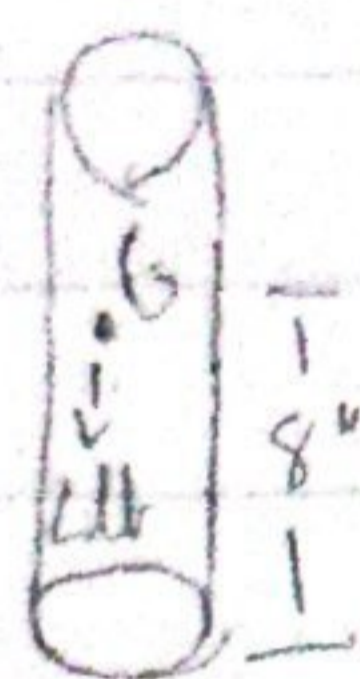
$\xrightarrow{+} \Sigma F_x = ma_{Gx} = 0.0621 \, a_{Gx}$

$\rightarrow ma_{Gx}$

$\uparrow \Sigma F_y = ma_{Gy} = N - 2 = 0$

$N = 2 \, lbs$

$\zeta \Sigma M_G = I_G \alpha \Rightarrow \theta F - 2x = 0$

$F = \mu_s N = 0.2(2) = 0.4 \, lb$

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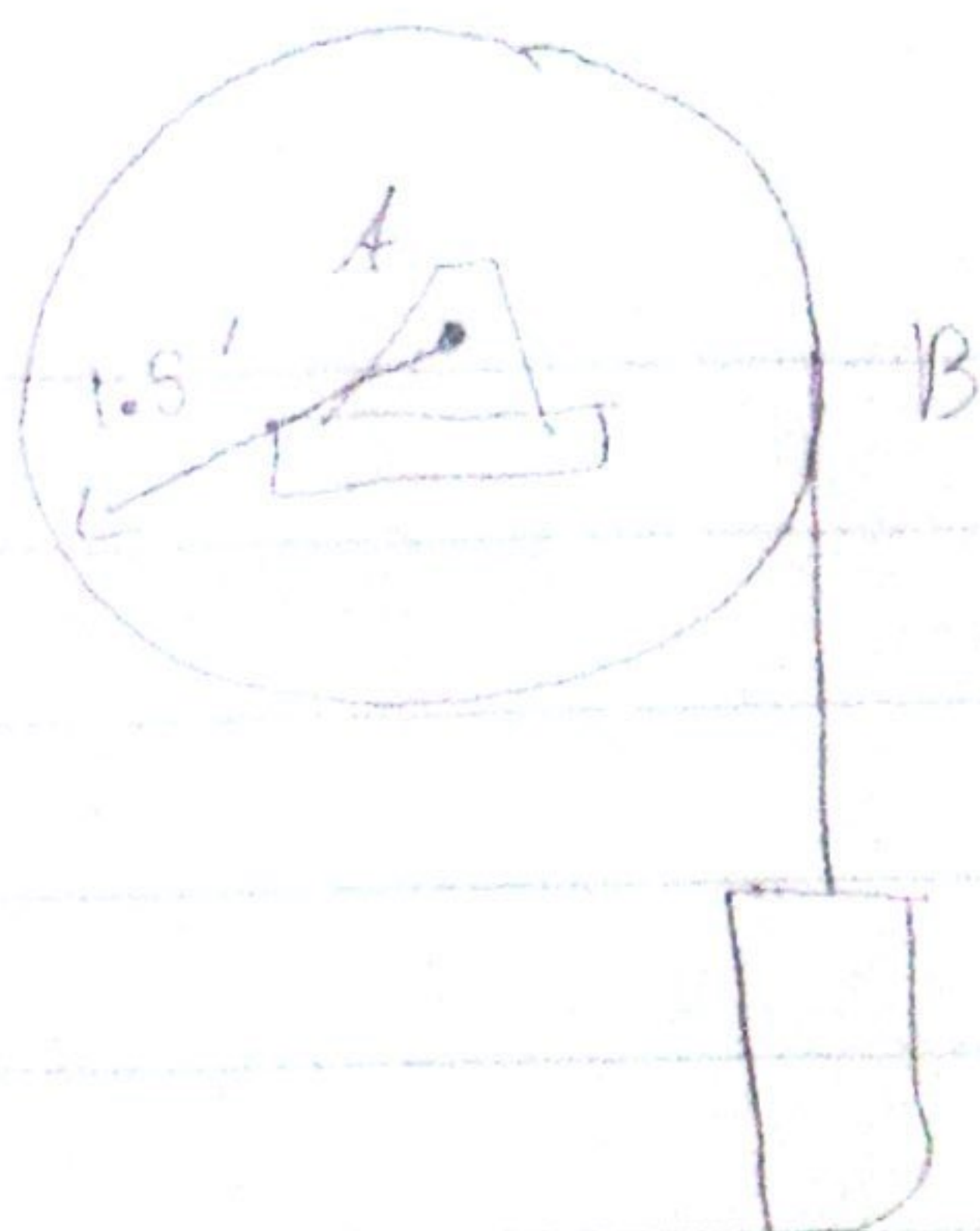
assume tipping

$x = 0.75$

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

$F = 0.1875 \quad 0.1875 = 0.0621 \, a_{Gx}$

$\boxed{a_{Gx \, max} = 3.02 \, ft/s^2}$

Force acceleration:

$$m \, drum = \frac{20lb}{32.2} = 0.621$$

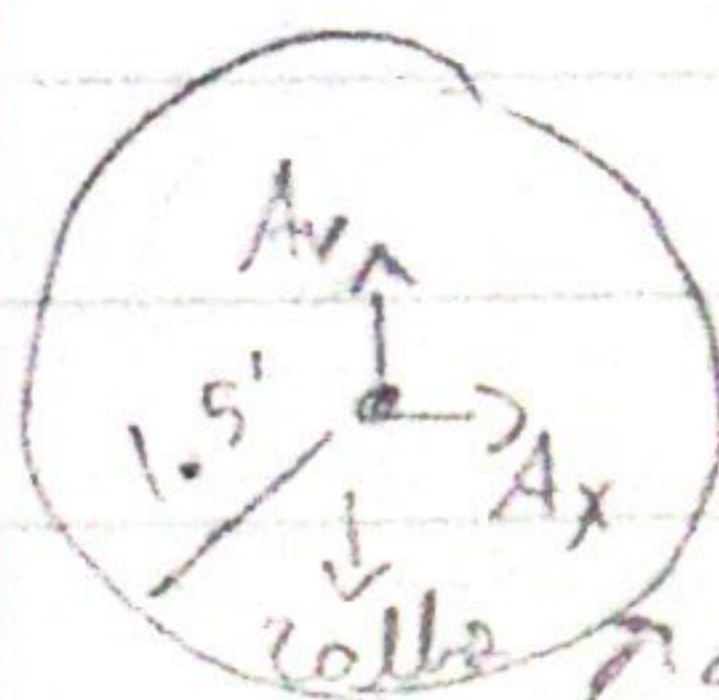$$I_G = 0.8ft, (0.621)(0.8^2) = 0.397$$

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

Properties:

$$I_G = mk^2$$

$$md = \frac{20}{32.2} = 0.621 \quad w_B = 12lbs$$

$$wd = 20lbs, \quad k = 0.8ft$$

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

FBD Wheel: =

Motion:

Drum: Rota

Block: Translation

KD wheel

$$\sum F_x = A_x = 0$$

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

$$\sum M = 1.5T = I_G \alpha$$

$$A_y - 20 = T \qquad \{1.5(A_y - 20) = 0.397\alpha$$

$$1.5T = 0.397\alpha \}$$

FBD Block: =

KD Block:

$$\sum F_y = T - 12 = m_a a_{Gy}$$

$$A_y - 20 - 12 = 0.373 a_{Gy}$$

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

$$A_y - 8 = 0.56\alpha \qquad \frac{A_y}{0.56} - 14.29 = \alpha$$

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

$m_p = 20\,kg$

$R_p = 0.5$

$m_{block} = 5\,kg$

$P = 100\,N$

$\mu_k = 0.15$
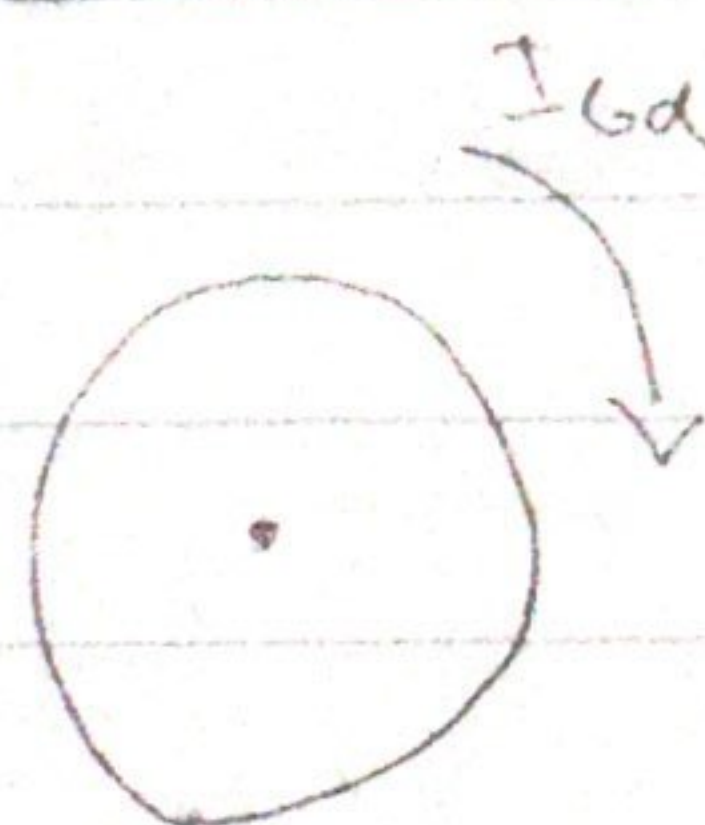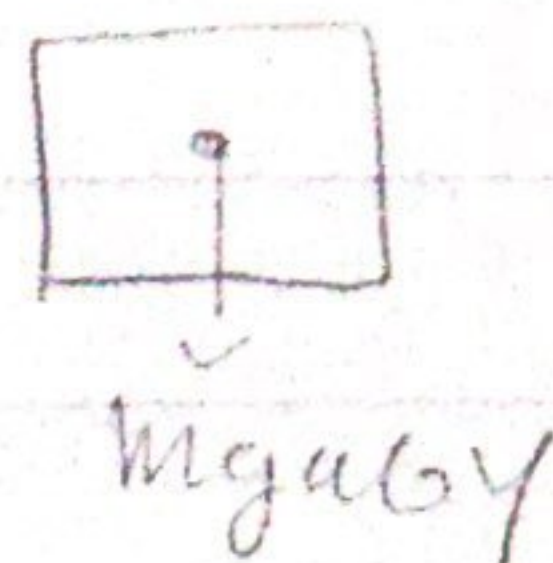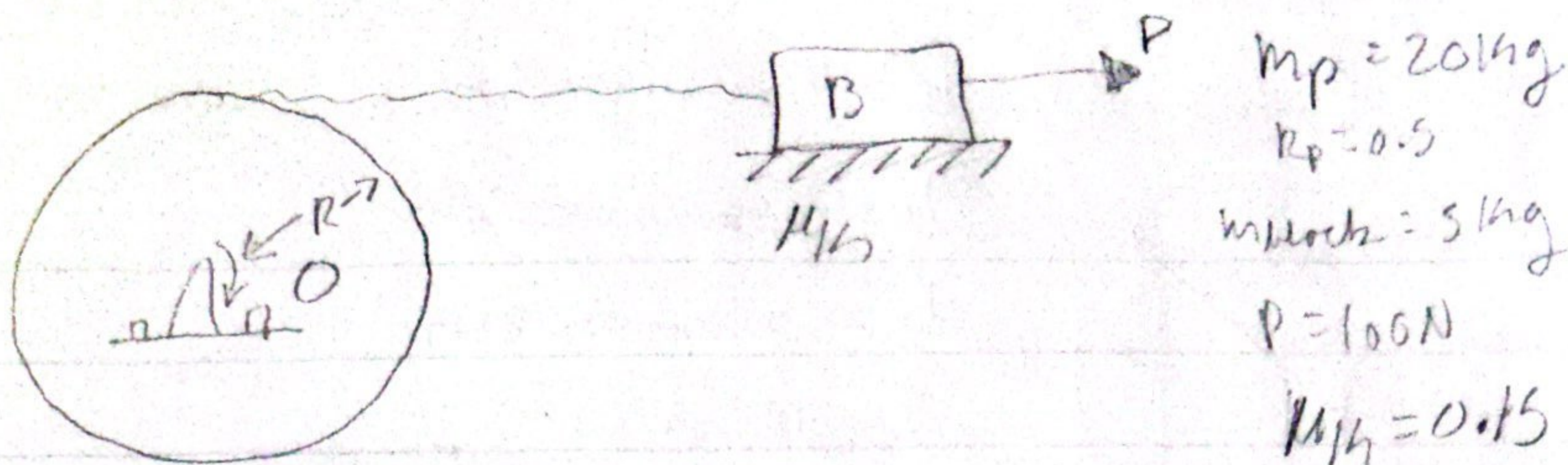
$\sum F_x = m_B A$ $\quad P - T - \mu_k\, m_{B}g = m_B A$

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

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

$\qquad\qquad 92.6425 - T = 5a \quad eqn\ 1$

$\sum M_O = I_O \alpha$

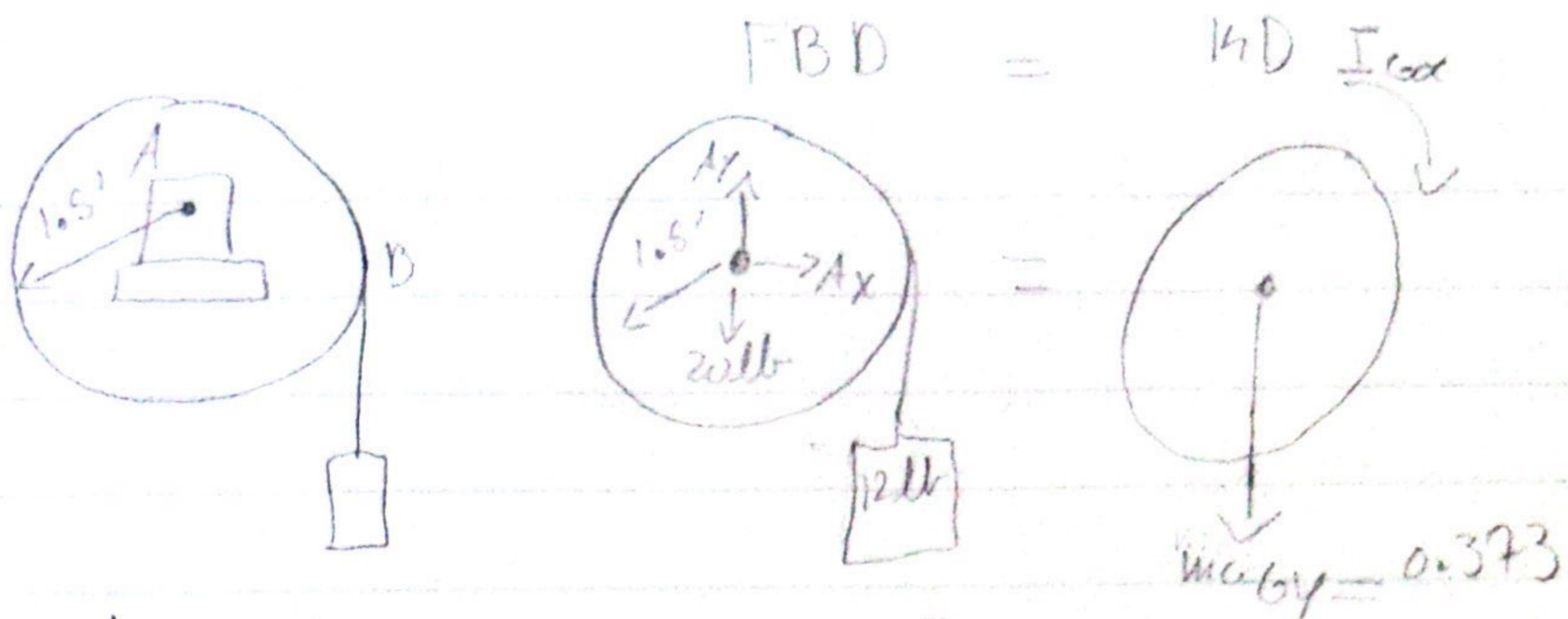$\qquad TR = I_O \alpha$

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

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

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

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

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

Force acceleration I: Problem 3

FBD = kD $I_G\alpha$

$ma_{Gy} - 0.373$

$W_D = 20\,lb$

$F = 12\,lb$ $\dfrac{12lb}{32.2} = \dfrac{M_B(32.2)}{32.2}$ $I_G = mk^2$

$k_z = 0.8\,ft$ $I_G = (0.621)(0.8)^2 = \boxed{0.3974}$

$F = ma$ $\boxed{M_B = 0.373}$

$m_D = \dfrac{20}{32.2} = 0.621$

$1.5\,ft$ $V_{\alpha B}^T$

$+\rightarrow \Sigma F_Y = ma_{Gx}$ $\curvearrowleft \Sigma M_g = I_G\alpha = 1.5T = -0.397\alpha$

$A_x = 0$ $\uparrow \Sigma F_y = M_B a_{Gy}$ $a_G = \alpha r_{pt/G}$
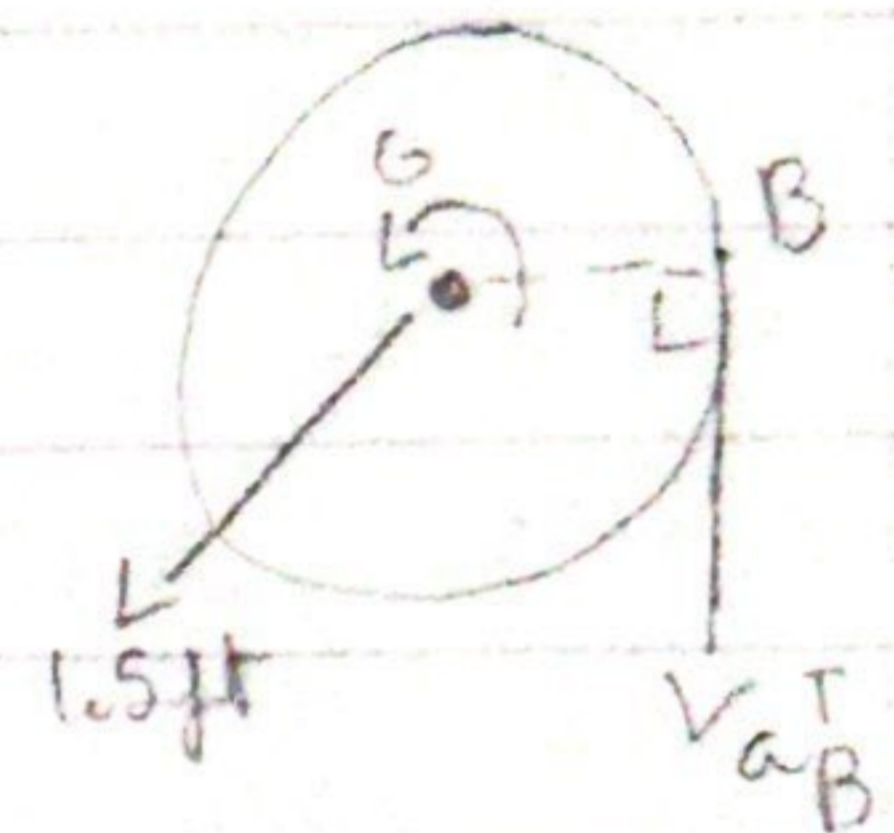
$\uparrow \Sigma F_y = ma_{Gy}$ $T - 12 = 0.373\,a_{Gy}$

$A_y - 20 - T = 0$ $a_B = 1.5\alpha \quad a_B = a_{Gy}$

$T - 12 = -(0.373)\,a_{Gy}$ $a_{Gy} = 1.5\alpha$

$a_T = \alpha\sqrt{}$ a Block $= a_B = a_{Gy} = 1.5\alpha$

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

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

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

$$\begin{bmatrix} 1 & 0.56 & 6 \\ -1 & 0 & 1 \\ 1.5 & 0.397 & 0 \end{bmatrix} \begin{Bmatrix} T \\ \alpha \\ A_y \end{Bmatrix} = \begin{Bmatrix} 12 \\ 20 \\ 0 \end{Bmatrix}$$
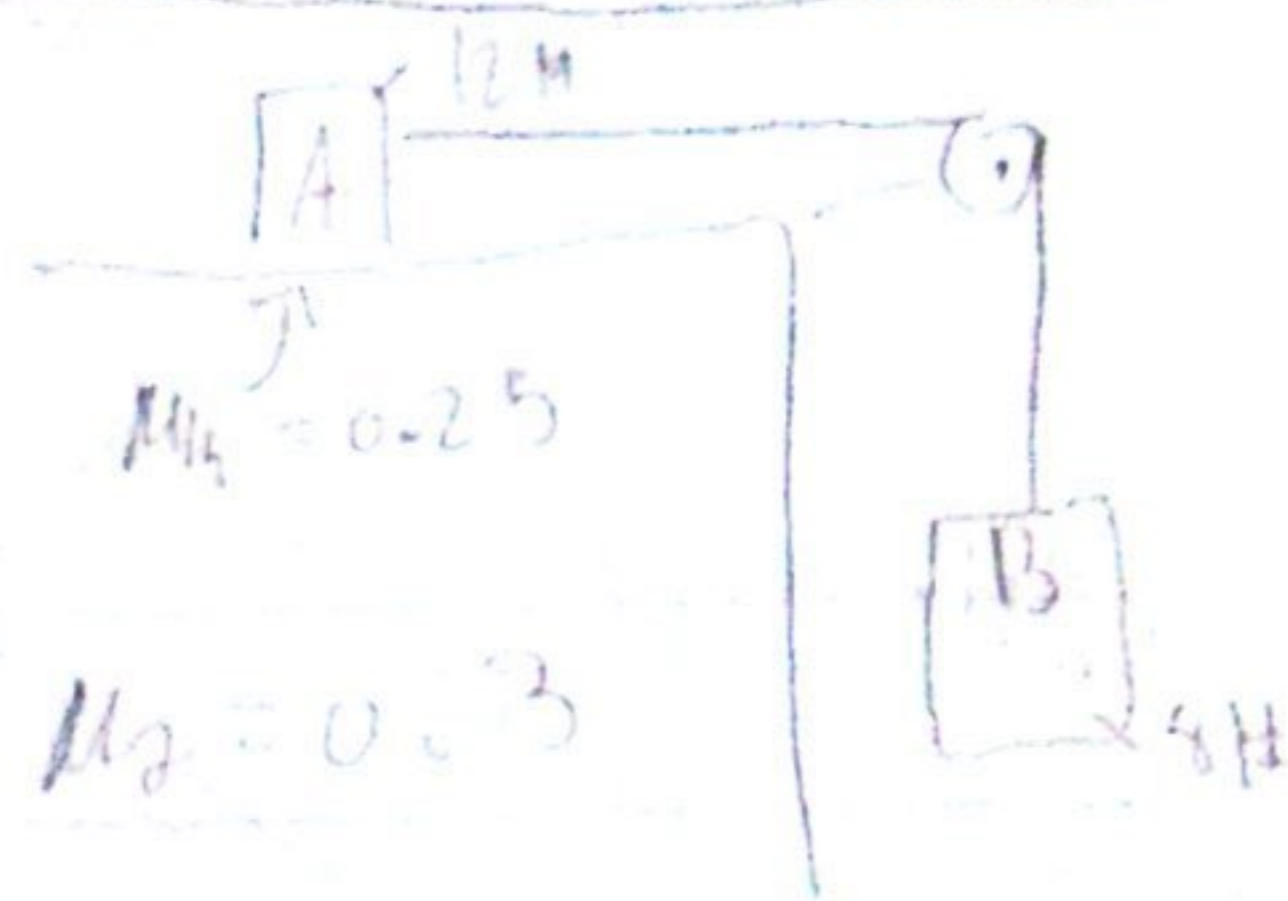
$T = 3.85\,lbs \quad a = 14.5\,rps^2 \quad A_y = 23.85\,lb$

$\Sigma M_G = I_G\alpha$

$1.5(12) = 0.397\alpha$

$\boxed{\alpha = 45.3\,rps^2}$

Force acceleration:

FBD = MD

A: $\mu_A = 0.25$

$\mu_B = 0.3$

A:
WA ↓, →T, ←F_F, ↑N_A

$m_A a_A$ →

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

B:
↑T
WB ↓
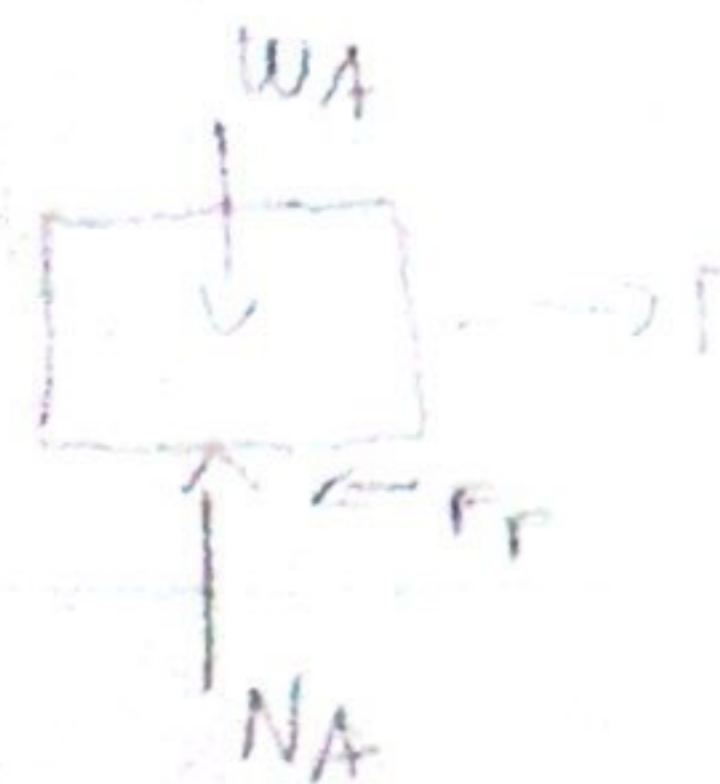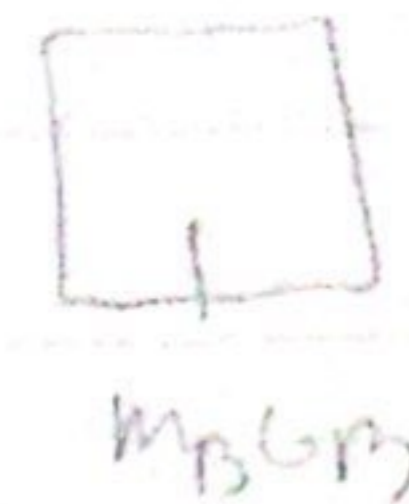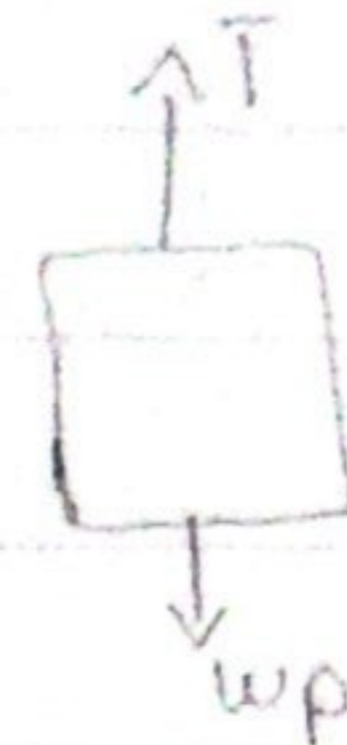
$m_B a_B$ ↓

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

A: $\Sigma x \Rightarrow T - F_F = m_A a_A$ ①   B: $\Sigma x \Rightarrow 0$

$\Sigma y \Rightarrow N_A - W_A = 0$ $\Sigma y \Rightarrow T - 8\# = m_B a_B$

$F_F = \mu N_a = (0.25)(12)$ $\dfrac{T-8}{-0.248} = a$ ②

$\boxed{F_F = 3\#}$ -0.248

$\Sigma x \Rightarrow T - F_F = m_A a$ $T - 3 = 0.373 \left(\dfrac{T-8}{-0.248} \right)$ $\dfrac{0.373}{0.248} = 1.504 (T-8)$
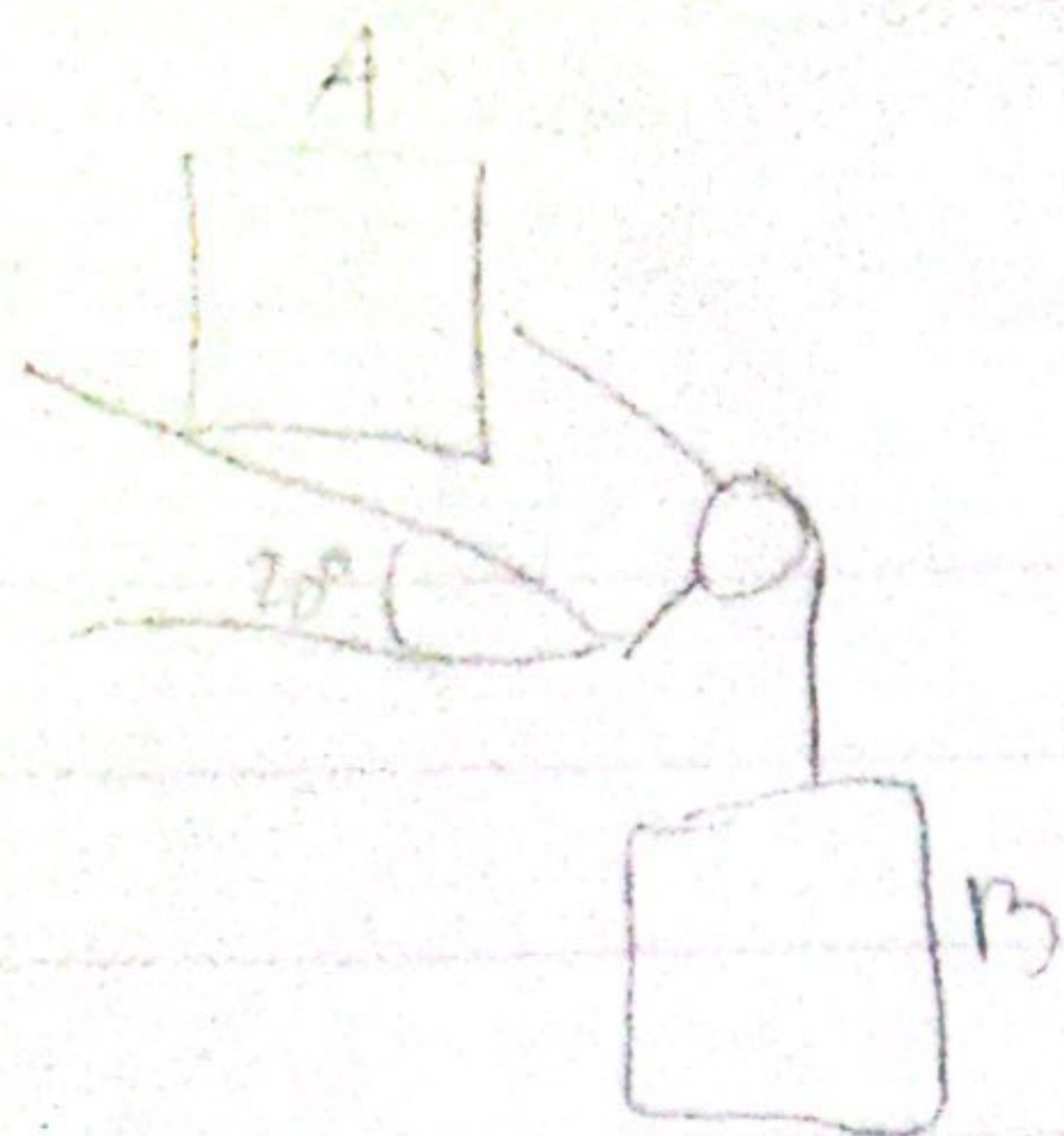
$T - 3 = 1.504 T + 12.03$ $1.504 T - 1.504 \times 8$

$2.504 T = 15.03$ $1.504 T - 12.032$

$\boxed{T = 6 \#}$

Force acceleration:

Classify motion:
Blocks A & B: Translation

Properties:
$M_A = 40\,kg$ $W_A = 40(9.8) = 392.4\,N$
$M_B = 30\,kg$ $W_B = 30(9.8) = 294.3\,N$
$\mu_s = 0.2$ & $\mu_{lh} = 0.15$

FBD = KD

392.4N

$= 40a_{G//}$

A:
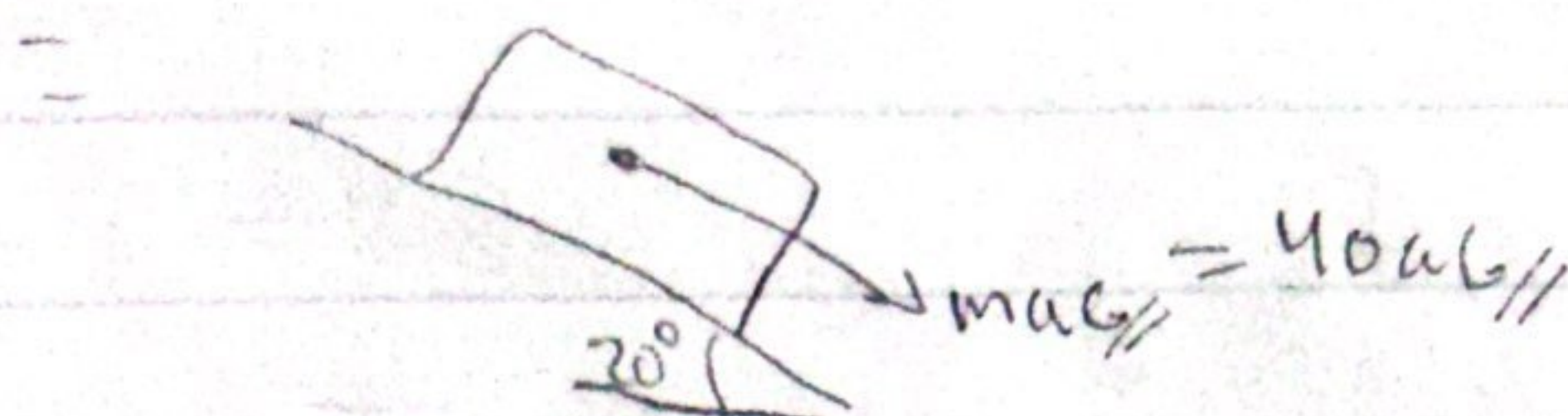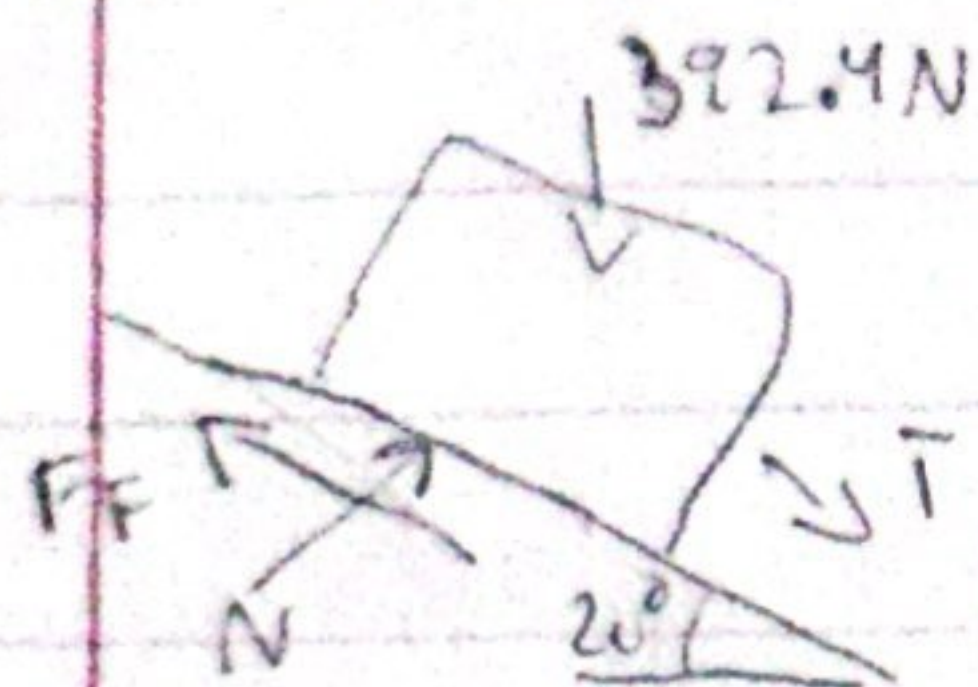
$$F_F = \mu_{lh} N = 0.15\,N = 0.15(369) = 55.4\,N$$

$$\nwarrow \Sigma F_\perp = ma_{G\perp} = N - 392.4\cos 20° = \varnothing \Rightarrow N = 369\,N$$

$$\searrow \Sigma F_{//} = ma_{G//} \Rightarrow T - F_F + 392.4\sin 20° = 40a_{G//}$$

$$T - 55.4\,N + 392.4\sin 20° = 40a_{G//}$$

$$① : T - 40a_{G//} = -78.86$$

B:

FBD = KD
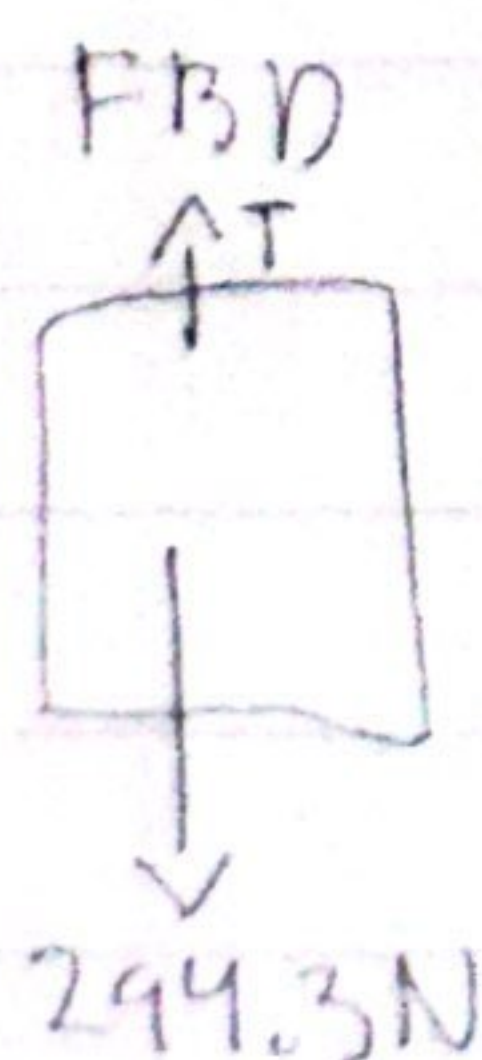
294.3N $m_B a_y = 30a_y$

$$② \downarrow \Sigma F_y = ma_{Gy} \Rightarrow 294.3 - T = 30a_y$$

Kinematic: $a_{G//} = a_y$
$(1)\ T - 40a_{G//} = -78.86$
$(2)\ T + 30a_{G//} = 294.3$

$$\boxed{T = 134\,N \quad a_{G//} = 5.32}$$

Force acceleration:

$M = 20 \text{ kg}$ $k_G = 250 \text{ mm}$ $\mu p = 0.1$
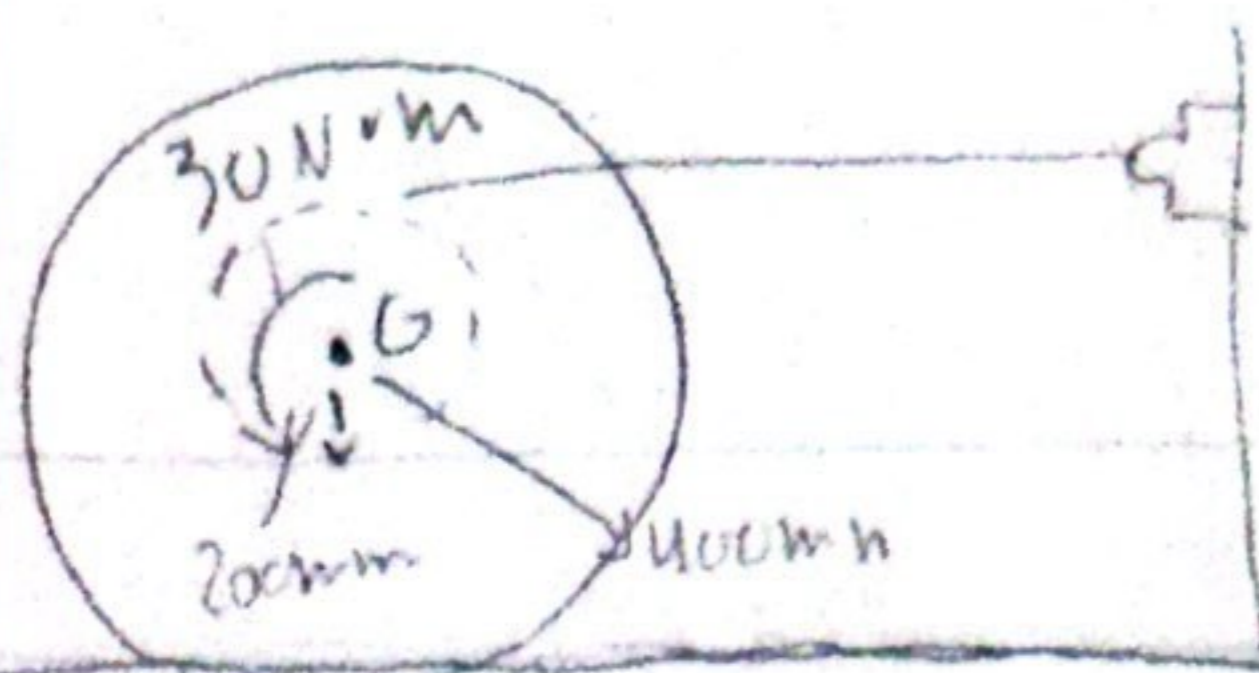
$C = 30 \text{ mm}$
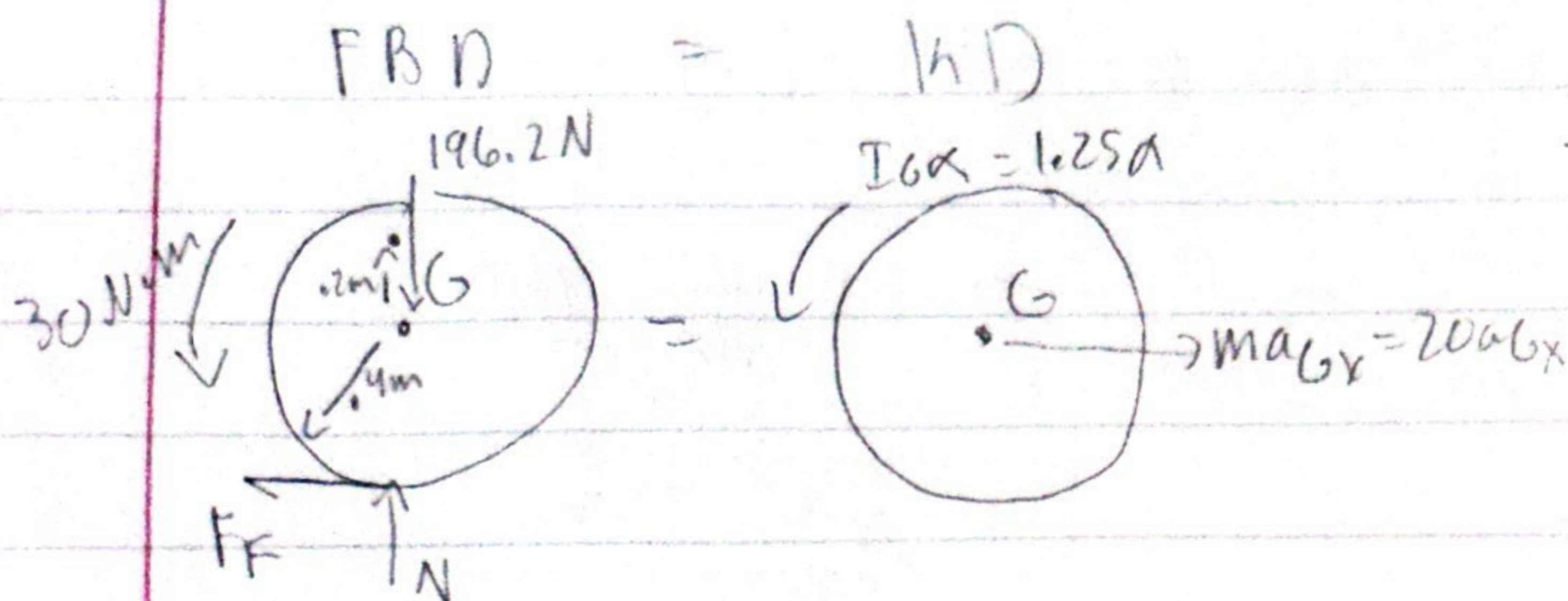

Classify motion
Spin

Properties

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

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

FBD = kD

196.2 N

$I_G \alpha = 1.25\alpha$

$\rightarrow ma_{Gx} = 20a_{Gx}$

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

$\xrightarrow{+} \Sigma F_x = ma_{Gx} \Rightarrow T - F_F = 20 a_{Gx}$ (1)

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

2 Eqn 4 unkn   must slide $F_T = \mu_B N = 0.1(196.2) = \boxed{F_F = 19.26 \text{ N}}$

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

① : $T - 19.26 = 20(0.2\alpha)$

② : $30 - 19.2(0.4) - T(0.2) = 1.25\alpha$

$T = 55.2 \text{ N} \ \& \ \alpha = 8.89$

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

$30 - 7.68 - 0.2T = 1.25a \Rightarrow 22.32 - 0.2T = 1.25$

$22.32 - 0.2(19.26 + 4a) = 1.25a$

$22.32 - 3.852 - 0.8a = 1.25a \Rightarrow 18.968 = 2.05a$

$\boxed{a = \dfrac{18.468}{2.05} = 9.0088}$

$\boxed{T = 19.26 + 4(9.0088) = 55.2951}$