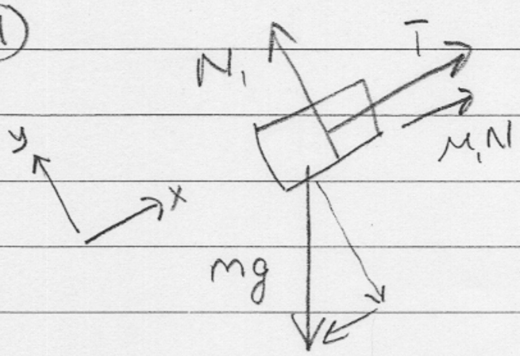
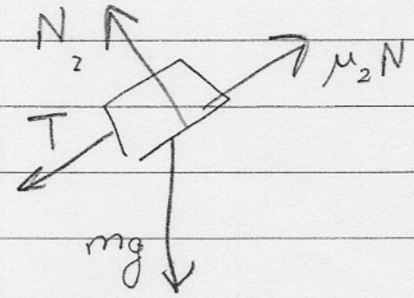
1





(5 pnts)

Then (10 pts)

x| $\mu_1 N + T - mg \sin\theta = m a_1$

x| $\mu_2 N - T - mg \sin\theta = m a_2$

y| $N_1 - mg\cos\theta = m\cancel{a_y}^{0}$

y| $N_2 - mg\cos\theta = m\cancel{a_y}^{0}$

3 pnts setup
2 pnts flow
3 pnts a
2 pnts T

$N_1 = N_2 = mg\cos\theta$

$\mu_1 mg\cos\theta + T - mg\sin\theta = ma$

$\mu_2 mg\cos\theta - T - mg\sin\theta = ma$

$(\mu_1 + \mu_2)\, mg\cos\theta - 2mg\sin\theta = 2ma$

(a) $\left(\frac{\mu_1 + \mu_2}{2}\right) g\cos\theta - g\sin\theta = a$

From

$$\mu_1 mg\cos\theta + T - mg\sin\theta = m\left[\frac{\mu_1+\mu_2}{2} g\cos\theta - g\sin\theta\right]$$

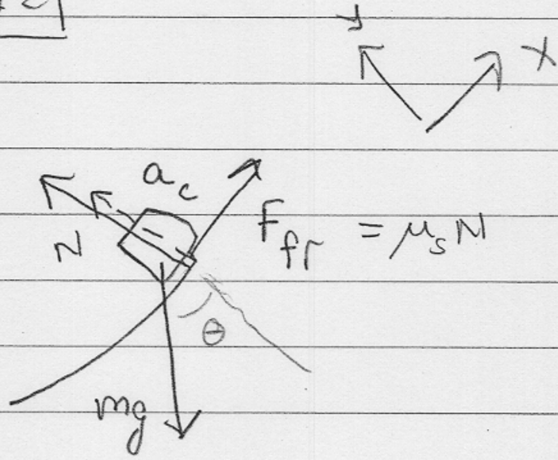
$$T = mg\left[\left(\frac{\mu_1+\mu_2}{2}\right)\cos\theta - \mu_1\cos\theta\right]$$

(b) $$T = \frac{mg}{2}\left(\mu_2 - \mu_1\right)\cos\theta$$

(2) If $\mu_2 = \mu_1$ then the then the tension is zero. This is because the two blocks are falling at the same rate 3pnt

(3) If the two blocks are reversed then block 2 would slide down and run into block 1 3pnts

Problem #2



(1)

2 pnts forces
2 pnts arrow

(2) From Newtons Law

$$-mg\cos\theta + N = m a_c = m\frac{(2\pi R)^2 f^2}{R} = m(2\pi)^2 f^2$$

$$\mu_s N - mg\sin\theta = m\cancel{a_x}^{\,0}$$

$$N = mg\frac{\sin\theta}{\mu_s}$$

8 pnts
- 2 Newton
- 2 v^2/R
- 2 ans
- 2 flow/algebr

$$-\cancel{m}g\cos\theta + \cancel{m}g\frac{\sin\theta}{\mu_s} = \cancel{m}(2\pi)^2 f^2 R$$

$$-\mu_s\cos\theta + \sin\theta = \frac{(2\pi)^2 f^2 R}{g}$$

(3) When $\mu_s \simeq 0$

$$\sin\theta = \mu_s\frac{(2\pi)^2 f^2 R}{g} + \mu_s\cos\theta$$

$\theta \propto \mu_s$ so $\theta \simeq 0$

$$\theta = \mu_s\left(1 + \frac{(2\pi)^2 f^2 R}{g}\right)$$

Julian Hessinger +2

Hao Wang 4/1 +7

Extra

(3) Note

$$\sin\theta = \mu_s u + \mu_s \cos\theta$$

$$\boxed{u \equiv \frac{(2\pi)^2 f^2 R}{g}}$$

$$\mu_s \cos\theta = -\mu_s u + \sin\theta$$

$$\mu_s^2 \cos^2\theta = (-\mu_s u + \sin\theta)^2$$

$$\boxed{s = \sin\theta}$$

$$\mu_s^2 (1 - s^2) = \mu_s^2 u^2 - 2\mu_s u s + s^2$$

$$0 = \mu_s^2 (u^2 - 1) - 2\mu_s u s + (\mu_s^2 + 1) s^2$$

$$s = \frac{1}{\mu_s^2 + 1} \left(\mu_s u \pm \sqrt{(\mu_s u)^2 - (\mu_s^2 + 1)(u^2 - 1)\mu_s^2} \right)$$

$$s = \frac{1}{1 + \mu_s^2} \left(\mu_s u \pm \sqrt{(\mu_s u)^2 - \mu_s^2 (u^2 - 1) - \mu_s^4 (u^2 - 1)} \right)$$

$$s = \frac{1}{1 + \mu_s^2} \left(\mu_s u \pm \mu_s \sqrt{1 + \mu_s^2 (1 - u^2)} \right)$$

(We want +, see below)

$$u \equiv \frac{(2\pi)^2 f^2 R}{g}$$

for $\mu_s \ll 1$: $\frac{1}{1 + \mu_s^2} \simeq 1$

$$\sqrt{1 + \mu_s^2 (1 - u^2)} \simeq 1$$

Extra

So find

$$S = \mu_s u + \mu_s$$

$$\sin\theta = \mu_s\left(1 + \frac{(2\pi)^2 f^2 R}{g}\right)$$

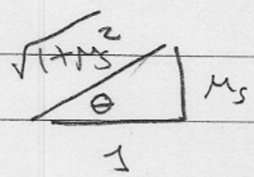
In general

$$\boxed{\sin\theta = \frac{1}{1+\mu_s^2}\left(\mu_s u + \mu_s\sqrt{1 + \mu_s^2(1-u^2)}\right)}$$

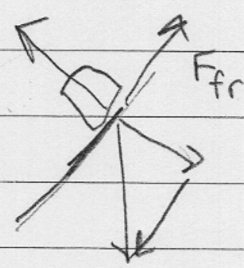
$$u = \frac{(2\pi)^2 f^2 R}{g}$$

When $f = 0$ $u = 0$:

$$\sin\theta = \frac{\mu_s}{\sqrt{1+\mu_s^2}}$$



$$\tan\theta = \mu_s$$



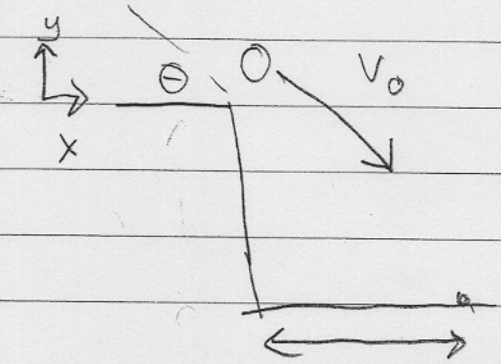
$$N - mg\cos\theta = 0$$

$$\Longrightarrow \quad \tan\theta = \mu_s$$

$$\mu_s N - mg\sin\theta = 0$$

Extra

(3)



By analyzing where it strikes the ground you can determine how fast it was going.

a) $x(t) = V_{ox}\, t$

$R = V_0 \cos\theta \, t_0 \Rightarrow t_0 = \dfrac{R}{V_0 \cos\theta}$ = When you hit the ground

b) $y = y_0 + V_{oy}\, t - \frac{1}{2} g t^2$

$-h = 0 - V_0 \sin\theta \, t_0 - \frac{1}{2} g t_0^2$

$0 = h - \cancel{V_0} \sin\theta \dfrac{R}{\cancel{V_0} \cos\theta} - \dfrac{1}{2} \dfrac{g}{V_0^2} \left(\dfrac{R}{\cos\theta}\right)^2$

$\dfrac{1}{2} \dfrac{g}{V_0^2} \left(\dfrac{R}{\cos\theta}\right)^2 = h - R\tan\theta$

5 pnts clue
5 pnts algebra

$g\left(\dfrac{R}{\cos\theta}\right)^2 = 2(h - R\tan\theta)\, V_0^2$

$$\boxed{\dfrac{R}{\cos\theta}\left(\dfrac{g}{2(h - R\tan\theta)}\right)^{\frac{1}{2}} = V_0}$$