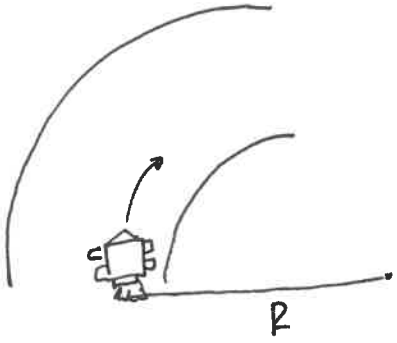
1

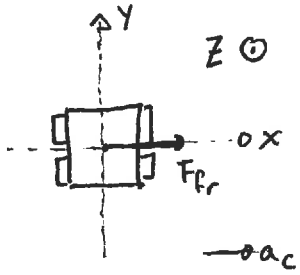


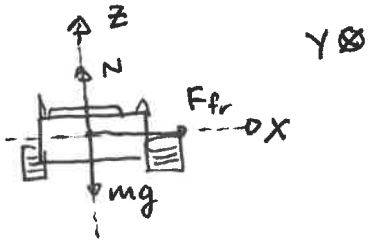
$R = 100m$

$m = 2000\,kg$

$\mu_s = 0.9$

Free body diagrams





X

$F_{fr} = m a_c$ —①

Y

N/A

Z

$N - mg = 0$ —②

$a_c = \frac{v^2}{R}$ —③

$F_{fr} = \mu_s N$ —④

②, solve for N.

$N = mg$ —②'

①—(②', ④, ③), solve for v.

$\mu_s N = m\frac{v^2}{R}$

$\mu_s mg = m\frac{v^2}{R}$

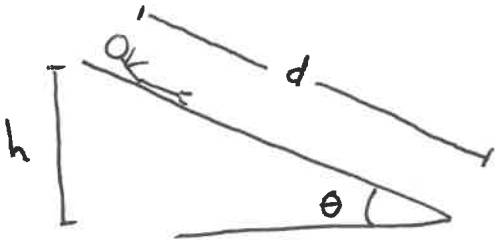
$v^2 = R\mu_s g$

$v = \sqrt{\mu_s R g}$

$v = \sqrt{(0.9)(100)(10)}$

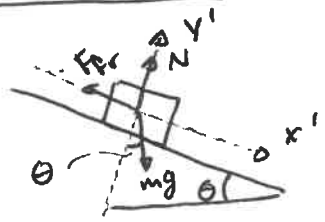
$\boxed{v = 30\,m/s}$

2



$V_0 = 0$ m/s
$m = 60$ kg
$\mu_k = 0.25$
$d = 10$ m
$h = ?$

Free body diagram

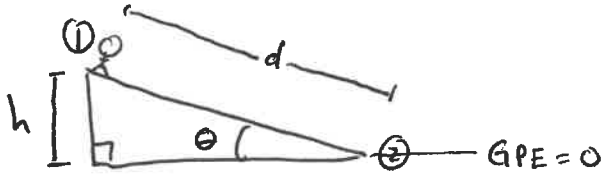


x'
$mg\sin\theta - F_{fr} = ma_x$ —①

y'
$N - mg\cos\theta = 0$ —②

$F_{fr} = \mu_k N$ —③

Energy Diagram



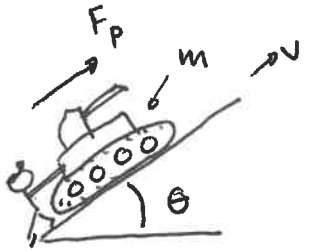
$\frac{h}{d} = \sin\theta$
$h = d\sin\theta$ —⑤

E① = E②
$GPE + \cancel{SPE}^{0} + \cancel{FE}^{0} + \cancel{KE}^{0} = \cancel{GPE}^{0} + \cancel{SPE}^{0} + FE + KE$
$mgh = \frac{1}{2}mv^2 + \mu_k N \cdot d$ —④

②, solve for N.
$N = mg\cos\theta$ —②'

④ — (②', ⑤), solve for V.
$mgd\sin\theta = \frac{1}{2}mv^2 + \mu_k mg\cos\theta \cdot d$
$\frac{1}{2}v^2 = gd(\sin\theta - \mu_k\cos\theta)$
$v = \sqrt{2gd(\sin\theta - \mu_k\cos\theta)}$
$v = \sqrt{2(10)(10)(\sin 30° - 0.25\cos 30°)}$
$v = 7.53$ m/s

3

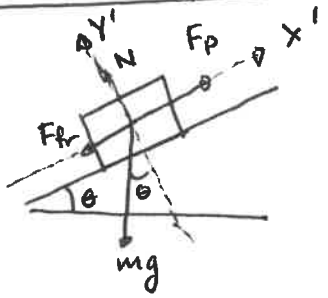


$F_p = 60{,}000\ N$ $\quad v = 1\ m/s$

$m = 5000\ kg$

$\theta = 30°$

Free Body Diagram



Constant velocity means $a = 0$.

X'

$F_p - mg\sin\theta - F_{fr} = 0$ —①

Y'

$N - mg\cos\theta = 0$ —②

$F_{fr} = \mu_k N$ —③

②, solve for N.

$N = mg\cos\theta$ —②'

① ← (②', ③), solve for μ_k.

$F_p - mg\sin\theta - \mu_k mg\cos\theta = 0$

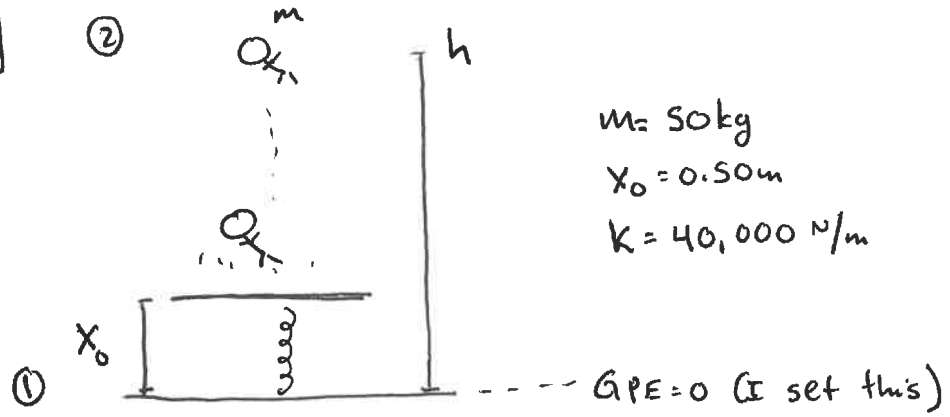
$F_p - mg\sin\theta = \mu_k mg\cos\theta$

$$\mu_k = \frac{F_p - mg\sin\theta}{mg\cos\theta}$$

$$\mu_k = \frac{60{,}000 - (5000)(10)\sin 30°}{(5000)(10)\cos 30°}$$

$\boxed{\mu_k = 0.81}$ ← note: this is unitless.

4



$m = 50\,kg$

$x_0 = 0.50\,m$

$k = 40{,}000\ N/m$

$E_①$ $\qquad$ $E_②$

$GPE^{0} + SPE + KE^{0} + FE^{0} = GPE + SPE^{0} + KE^{0} + FE^{0}$

$$\frac{1}{2}kx_0^2 = mgh \quad — \quad ①$$

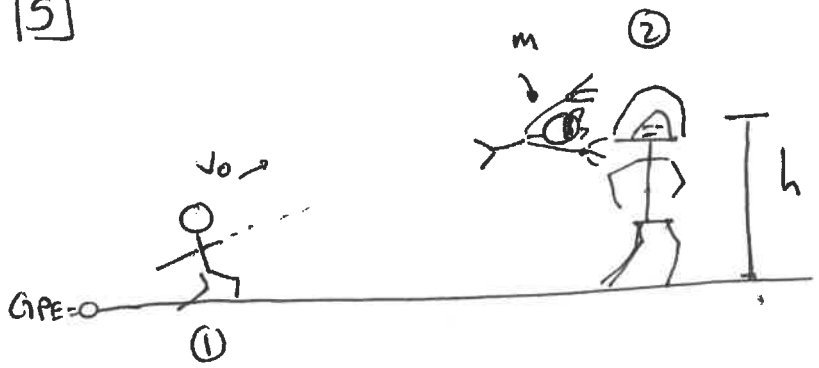
① solve for h.

$$h = \frac{\frac{1}{2}kx_0^2}{mg} = \frac{kx_0^2}{2mg}$$

$$h = \frac{(40{,}000)(0.5)^2}{2(50)(10)}$$

$$\boxed{h = 10\,m}$$

5



$m = 80\ kg$
$h = 5\ m$
$v_0 = 30\ m/s$

$E_①$ $\qquad$ $E_②$

$GPE^{\circ} + SPE^{\circ} + KE_1 + FE^{\circ} = GPE + SPE^{\circ} + KE_2 + FE^{\circ}$

$$\frac{1}{2}mv_0^2 = mgh + \frac{1}{2}mv_f^2 \quad \text{—— ①}$$

①, solve for v_f.

$$\frac{1}{2}v_0^2 = gh + \frac{1}{2}v_f^2$$

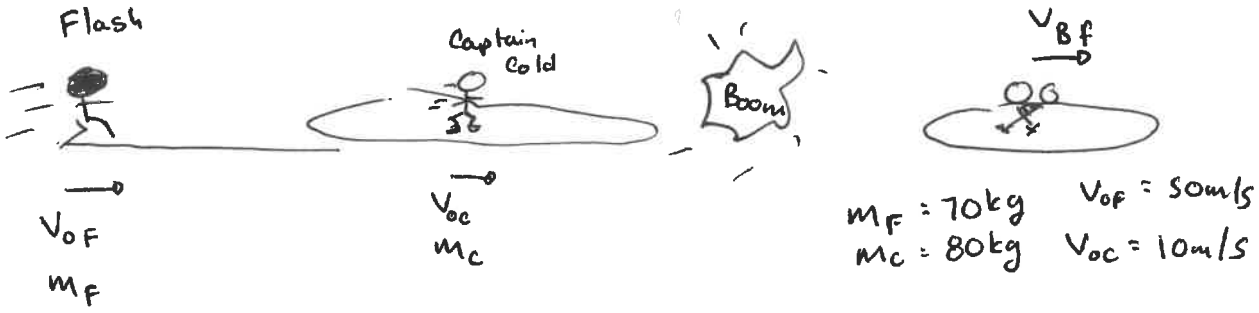
$$v_0^2 - 2gh = v_f^2$$

$$v_f = \sqrt{v_0^2 - 2gh}$$

$$v_f = \sqrt{(30)^2 - 2(10)(5)}$$

$$\boxed{v_f = 28.3\ m/s}$$

6



Cannot use conservation of energy.

Use conservation of momentum (collision)

X

$P_{ix} = P_{fx}$

Y

$P_{iy} = P_{fy}$

$$m_F V_{oF} + m_c V_{oc} = (m_F + m_c) V_{Bf} \quad -①$$

①, solve for V_f.

$$V_{Bf} = \frac{m_F V_{oF} + m_c V_{oc}}{m_F + m_c}$$

$$V_{Bf} = \frac{(70)(50) + (80)(10)}{70 + 80}$$

$$\boxed{V_{Bf} = 28.7 m/s}$$