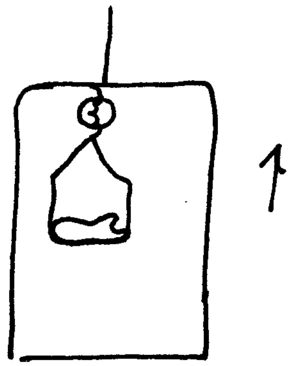
MORE NEWT'S LAWS / FRICTION

NEWTON'S 3RD LAW PAIRS



$F_{ROPE-ELEV}$ ↑

$F_{ELEV-ROPE}$ ↓

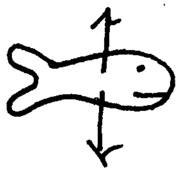
$F_{ELEV-SPRING}$ ↑

$F_{SPRING-ELEV}$ ↓

SPRING CAN STRETCH

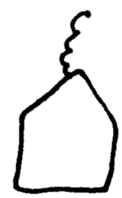
(This is what tells us the weight)

FREE BODY DIAGRAM



$F_{SCALE-FISH}$

W



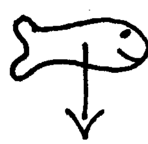
$F_{SPRING-SCALE}$ ↑

$F_{SCALE-SPRING}$ ↓

(all of the rest of this stuff is irrelevant to case of fish's motion)

$F_{SCALE-FISH}$ ↑

$F_{FISH-SCALE}$ ↓



$F_{FISH-EARTH}$ ↑

W_{FISH} ($F_{EARTH-FISH}$)

+ comparable for spring scale elev

Scale says 55 N

This means that the spring is stretched by an amt x corresponding to a force of 55 N

$$F_{SPRING-SCALE} = F_{SCALE-FISH} = 55\,N$$

$$\Sigma F = ma \qquad F_{SCALE-FISH} - W = ma$$

$55N - mg = ma$ Don't know W or m

$55N = m(g+a) = m\,(9.8ms^{-2} + 2.45ms^{-2})$

$m = 55N / 12.25ms^{-2} = 4.49\,kg.$

$W = mg = 4.49\,kg \cdot 9.8ms^{-2} = 44\,N$

What if Balance reads 25 N (n.b. if F_{SCALE} is $< W$ then the elevator must be falling)

$25N - 44N = ma$

$a = -\dfrac{19N}{4.49\,kg} = -4.2\ ms^{-2}$

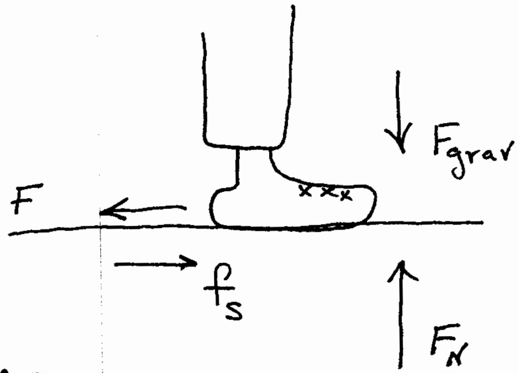
What will balance read if elevator is moving upwards with $v = 2\ ms^{-1} = const$

$F_{scale} = 44\,N$ ($v = const \Rightarrow a = 0$, $\Sigma F = 0$)

What if balance is accelerating downward with $\vec{a} = 9.8ms^{-2}$ (cable breaks)

"FISH IS WEIGHTLESS"

$F_{SCALE} = 0$



We push backward with force F; f_s prevents our foot from slipping and thus provides the force for forward propulsion

NB STATIC friction if foot doesn't slip

$$\mu_s \approx 0.5 \ \left(\text{leather concrete}\right) \qquad 1.0 \ \left(\text{Rubber on track}\right)$$

$$F_g = mg = F_N$$

$$f_s \leq \mu_s F_N = \mu_s mg$$

$$= m \cdot 4.9\,\mathrm{m\,s^{-2}} - m \cdot 9.8\,\mathrm{m\,s^{-2}}$$

If this force accelerates us forward e.g. 100 m dash

$$ma = F \leq f_s^{max} = \mu_s mg$$

$$a^{max} = \mu_s mg$$

$t=0$ $\qquad$ $t=t$

$d=0$ $\qquad$ $d=100\,\mathrm{m}$

$v_0=0$ $\qquad$ $a=\mu_s m g$ $\qquad$ $v=?$

$$d = \cancel{d_0} + \cancel{v_0 t}^{\,0} + \tfrac{1}{2}at^2$$

$$100\,\mathrm{m} = \tfrac{1}{2}at^2$$

$$t = \left(\frac{200\,\mathrm{m}}{\mu_s m g}\right)^{1/2} = 6.4^s \qquad 4.5\,\mathrm{s}$$

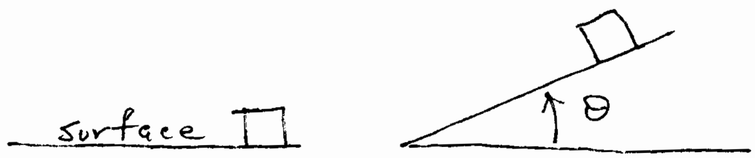
World record is about 9.8 s

Notice that if you push so hard that your foot slips

$$F_{RUNNER} = f_k = \mu_k mg$$

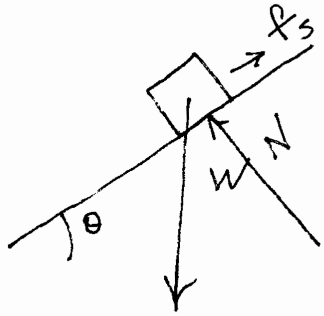
and μ_k is only about $\frac{1}{2}$ as great. That's why spinning your wheels coming out of a stop-sign or stop light is inefficient.

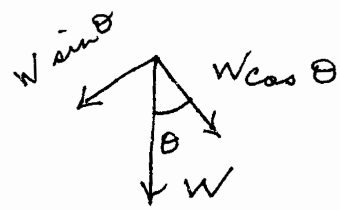
We can measure the coeff't of friction



Rotate surface through angle until block just begins to slip. At that θ

$$f_s = f_s^{max} = \mu_s N$$



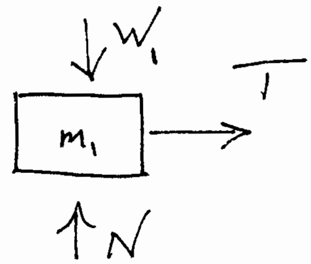


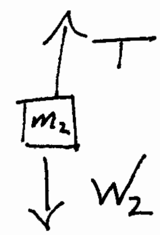
Along plane $\quad f_s^{max} = W\sin\theta = \mu_s N$

$\perp$ plane $\quad N = W\cos\theta$

$$\mu_s N = \mu_s \cancel{W}\cos\theta = \cancel{W}\sin\theta$$

$$\boxed{\mu_s = \tan\theta}$$





$m_1 = 10$ kg

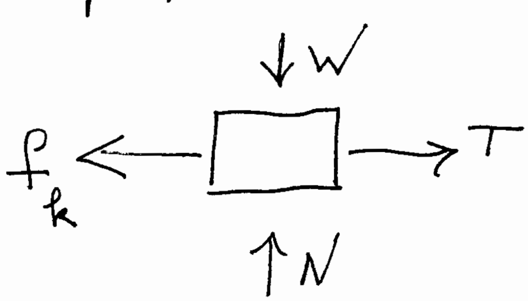
$m_2 = 5$ kg

(1)	$T = m_1 a$	$T - f_k = m_1 a$
(2)	$W_2 - T = m_2 a$	$T - \mu_k m_1 g = m_1 a$

combine: $W_2 = m_2 g = (m_1 + m_2) a$

$$a = \frac{m_2}{m_1 + m_2} g$$

If friction: $T = m_1 a = \dfrac{m_1 m_2}{m_1 + m_2} g$



What is condition for motion $a > 0$

$$T - f_s > 0$$

$$T - \mu_s m_1 g > 0 \quad \text{or } T > \mu_s m_1 g$$

$$W_2 - T = m_2 a$$

$$\underline{\underline{\text{need}}} \quad W_2 > \mu_s m_1 g$$

then $f \rightarrow f_k$

$$T - \mu_k m_1 g = m_1 a$$

$$W_2 - T = m_2 a$$

$$W_2 - \mu_k m_1 g = (m_1 + m_2) a$$

$$m_2 g - \mu_k m_1 g = (m_1 + m_2) a$$

$$a = \frac{(m_2 - \mu_k m_1)}{m_1 + m_2} g$$