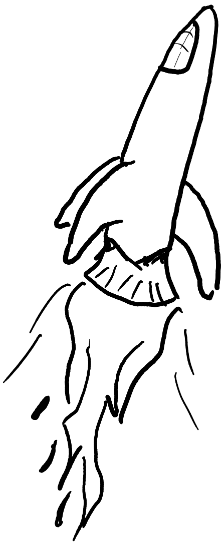
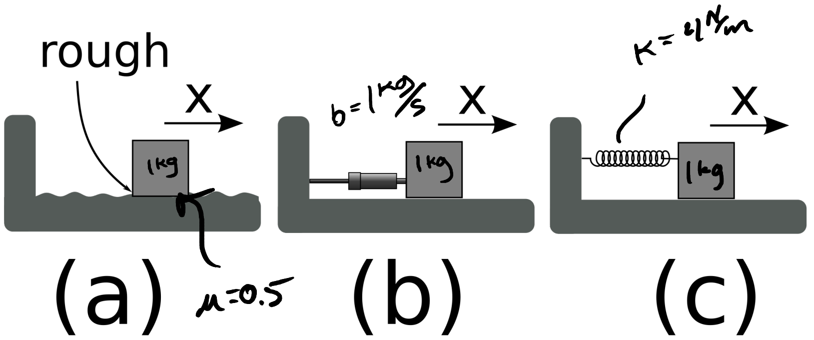


Draw FBD

why like that?

include drag, wind,
thrust,
gravity

To be
con'd



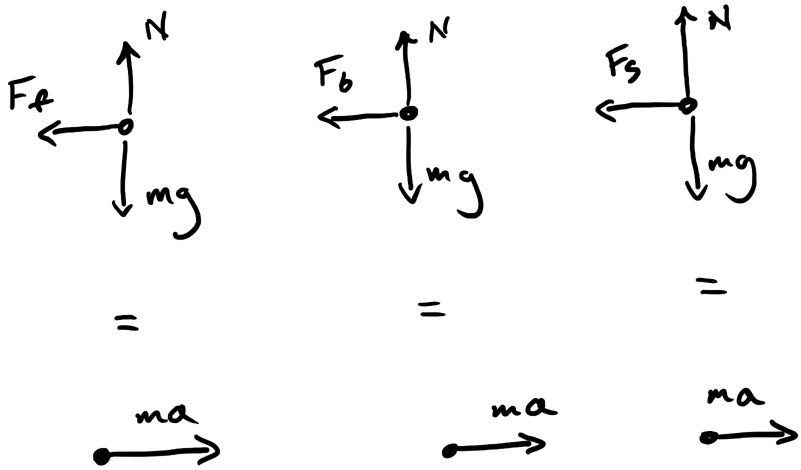
damping

$F_b = b \cdot v = b\dot{x}$

$F_f = \mu m g$

$F_b = b\dot{x} = bv$

$F_s = kx$



Cooper's shorthand

$\frac{dx}{dt} = \dot{x}$

$\frac{d^2x}{dt^2} = \ddot{x}$

(a) $-\mu m g = ma$ (when $v>0$)

(b) $-bv = ma$

(c) $-kx = ma$

given
$x(0) = 0$ m
$v(0) = 10$ m/s

(a) $a = -0.5 \cdot g$

$x(t) = -\frac{1}{2} \cdot 0.5 \cdot g\, t^2 + 10t + 0$ $\rightarrow$ when accel is constant use kinematic eqns

(b) $\frac{dv}{dt} = -\frac{b}{m} v$

$$\frac{dv}{dt} \cdot \frac{1}{v} \neq \frac{d}{dt}$$

$$\frac{dv}{v} = \frac{-\frac{b}{m} \cdot v \cdot dt}{v}$$

$$\int_{v_0}^{v(t)} \frac{1}{v} \cdot dv = \int_0^t -\frac{b}{m} \cdot dt$$

$$\ln(v) - \ln(v_0) = -\frac{b}{m}(t-0)$$

$$\ln\left(\frac{v}{v_0}\right) = -\frac{b}{m} t$$

$$e^{\ln(v/v_0)} = e^{-b/m \cdot t}$$

$$\Downarrow$$

$$\frac{v}{v_0} = e^{-b/m\, t}$$

$$\Downarrow$$

$$v(t) = v_0 \cdot e^{-b/m\, t}$$

$$\frac{dx}{dt} = v(t) = v_0 \cdot e^{-b/m\, t}$$

$$\int_{x(0)}^{x(t)} dx = \int_0^t v_0 e^{-b/m\, t} \cdot dt$$

$$x(t) - x_0 = -v_0 \cdot \frac{m}{b}\left(e^{-b/m\, t} - e^0\right)$$

$$x(t) = v_0 \cdot \frac{m}{b}\left(1 - e^{-b/m\, t}\right)$$

note:

$$\frac{d}{dt}\left(e^{-bt}\right) = -b e^{-bt}$$

$$\int e^{-bt} = -\frac{1}{b} e^{-bt}$$