Drag

Moving through a fluid, or a fluid moves past you.

~~Air resistance~~

~~Wind resistance~~

~~Air friction~~

The term "Drag" covers all of these.

Fluid = anything that flows (any gas or liquid)

Moving through a fluid, or a fluid moves past you.

Surfaces scraping over each other

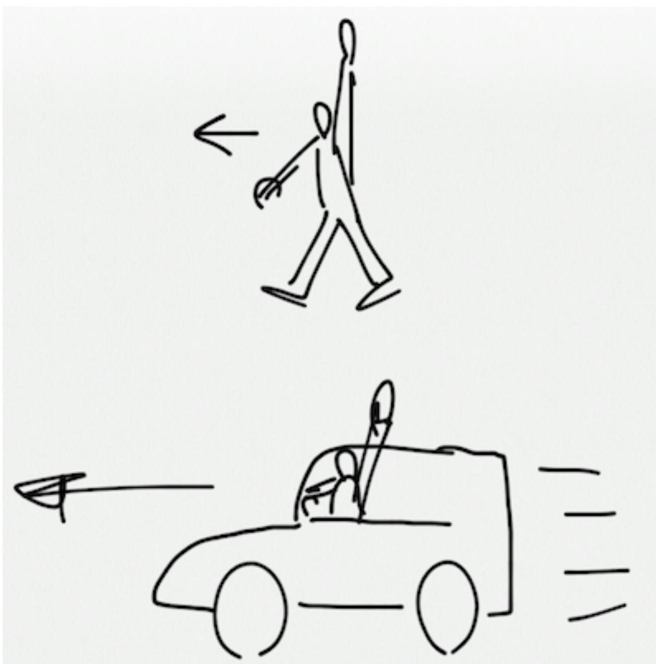
Drag ≠ Friction

Depends on

- ???

Depends on

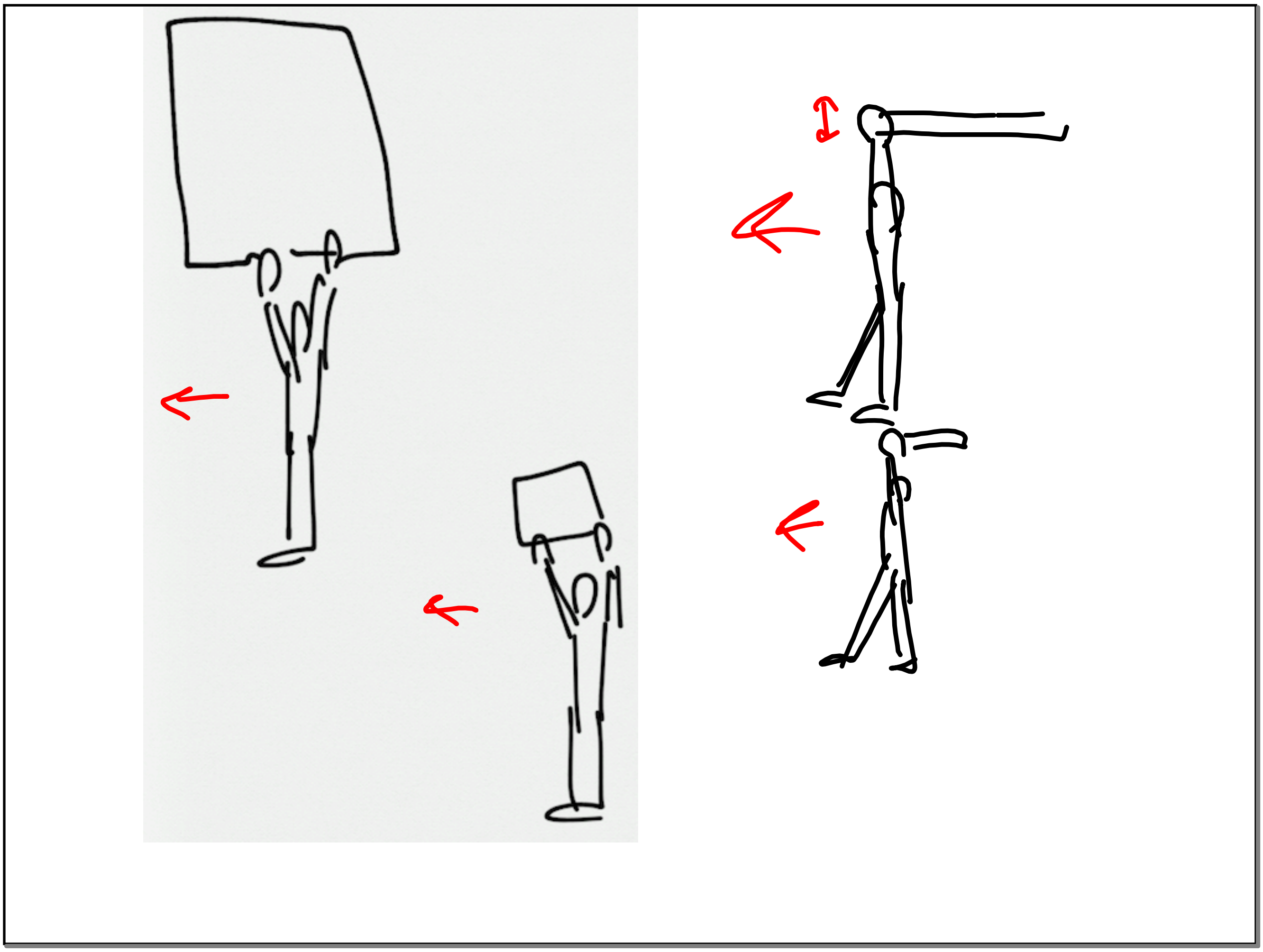
- The surfaces
- The force holding the surfaces together

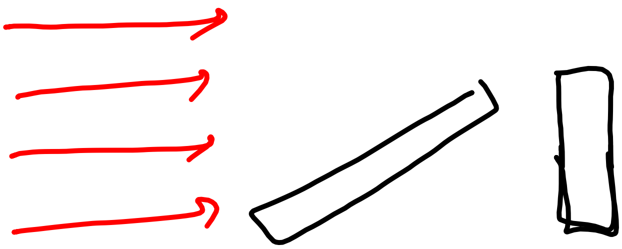


velocity

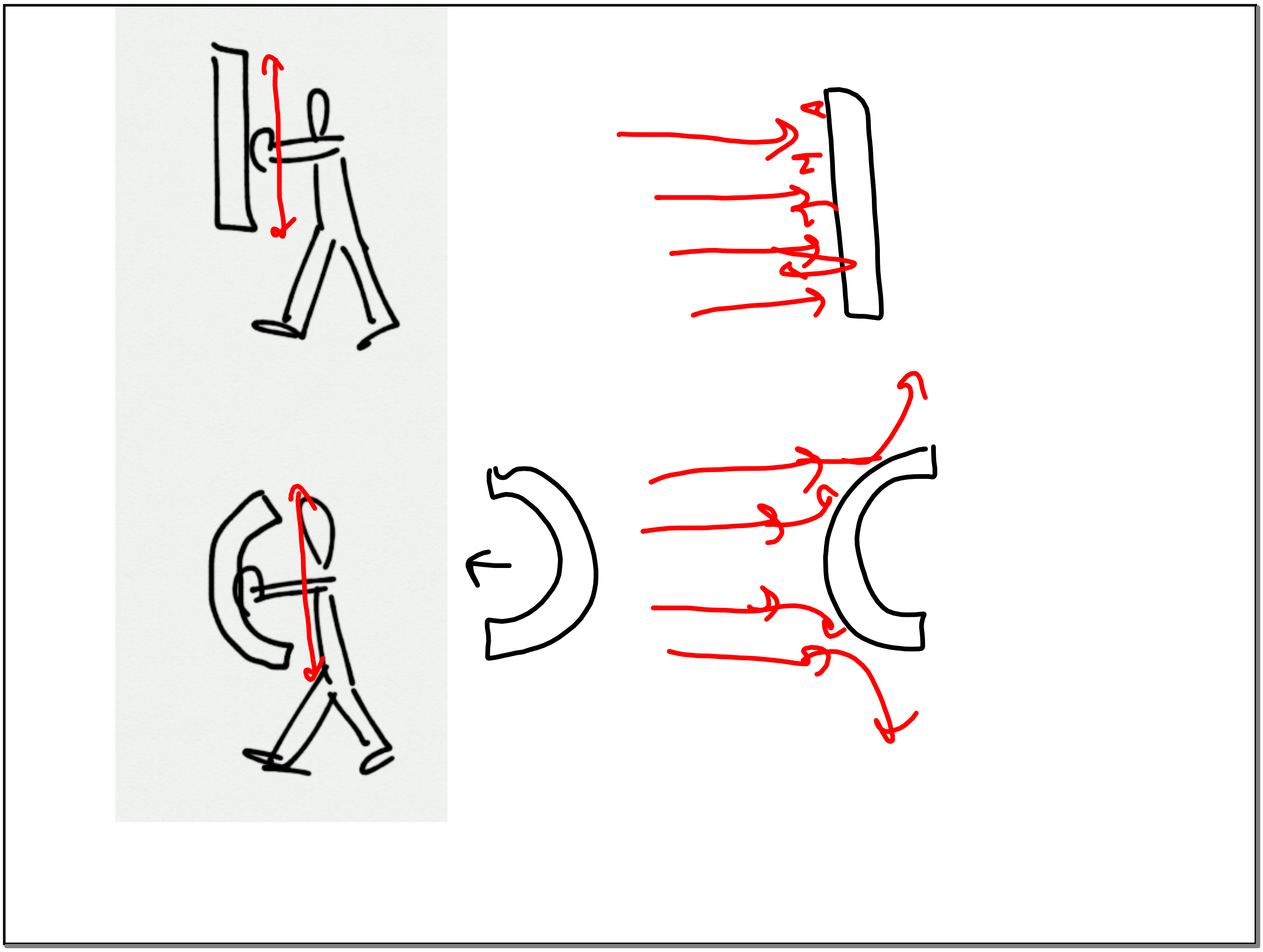
~~speed~~

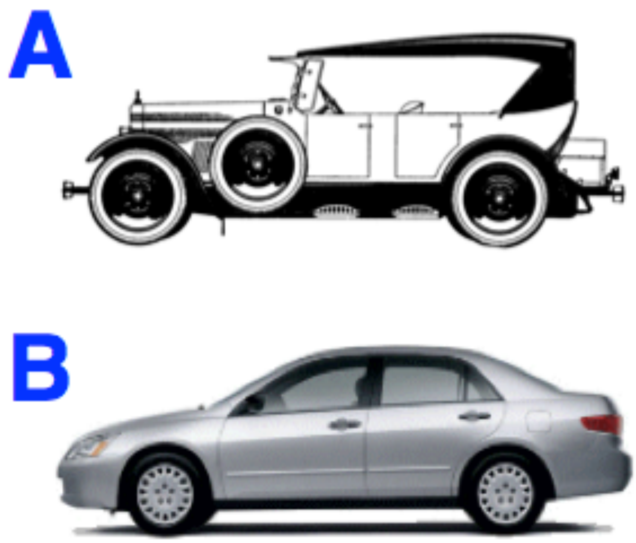
D = —

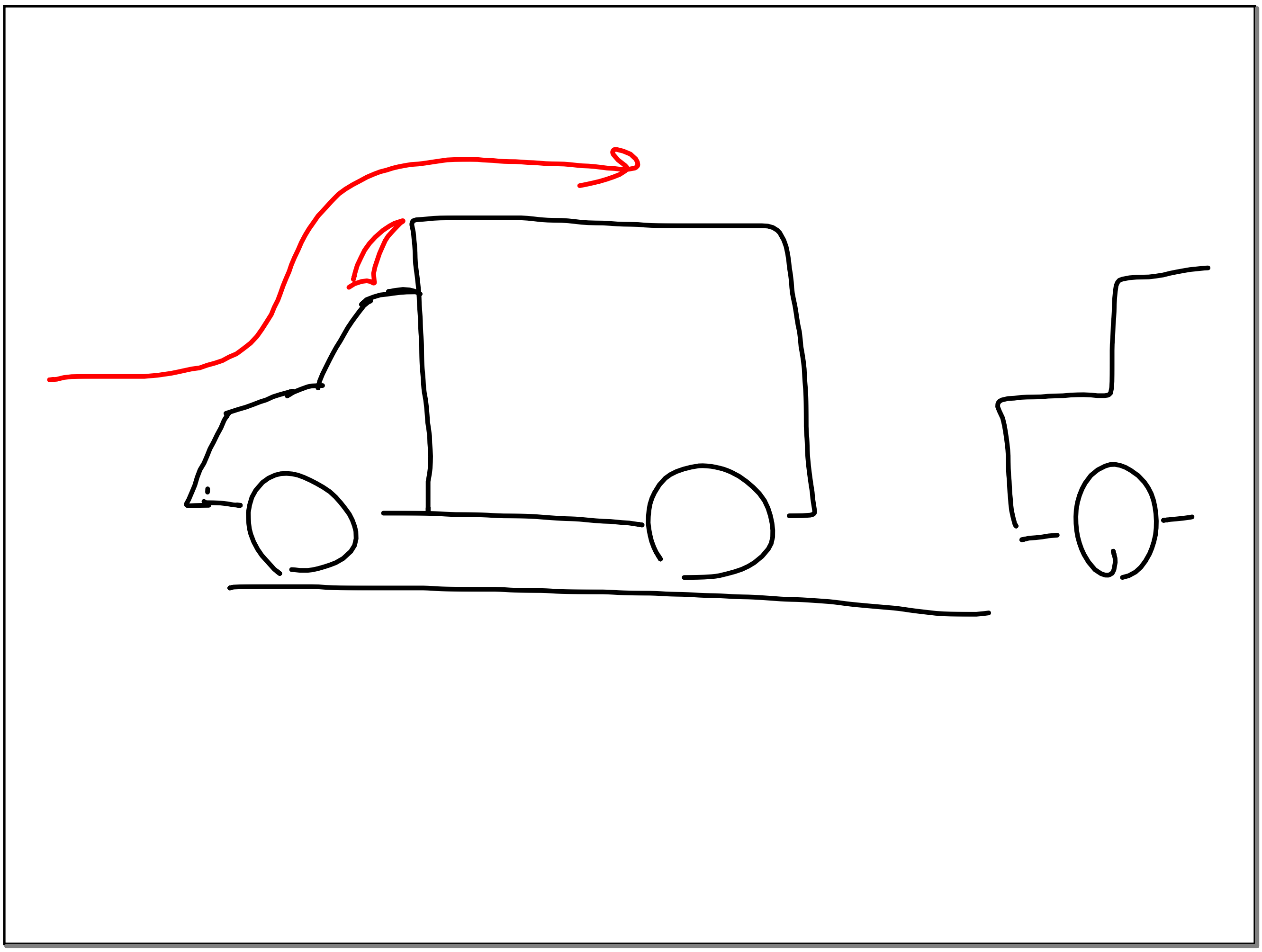


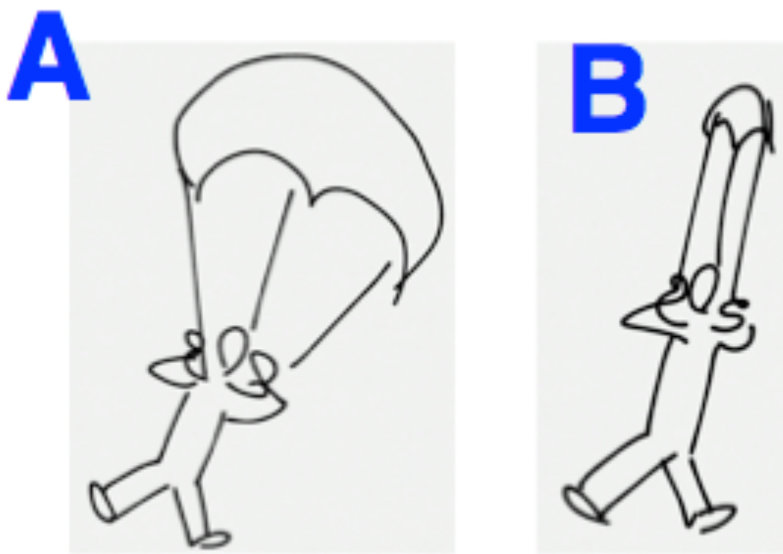


equivalent surface area
is perpendicular to flow




A
B

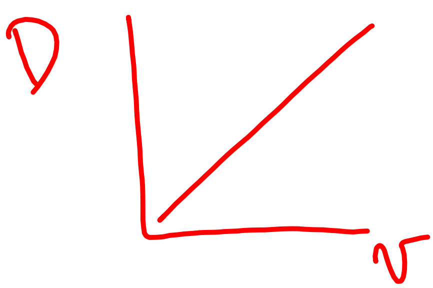



A
B

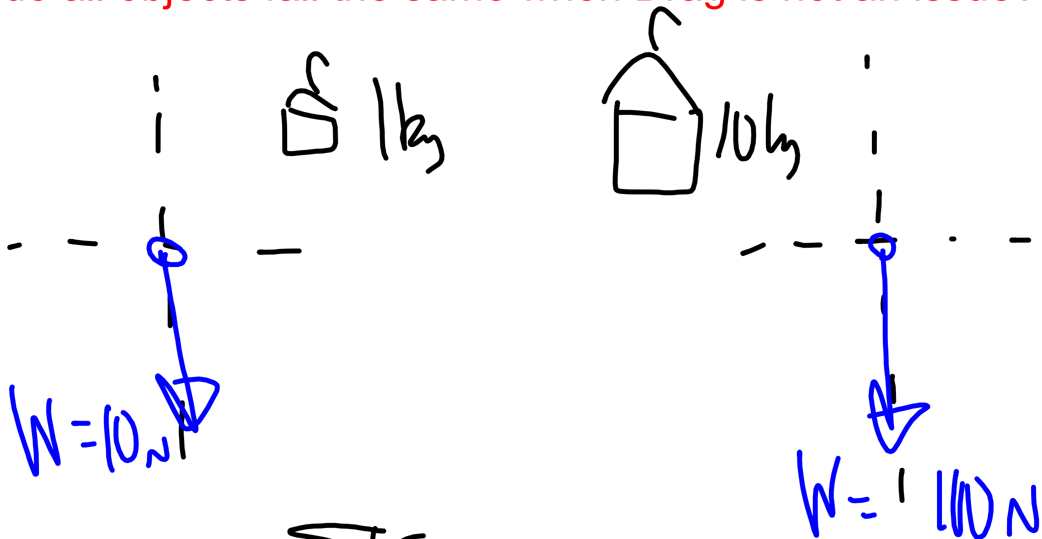
$$D = (\text{shape})(\text{suface} \perp)\left(\begin{matrix}\text{density} \\ \text{viscosity}\end{matrix}\right) v$$

$$D = -kv^n$$

$$D = -kv \quad \text{or} \quad -kv^2$$



Why do all objects fall the same when Drag is not an issue?



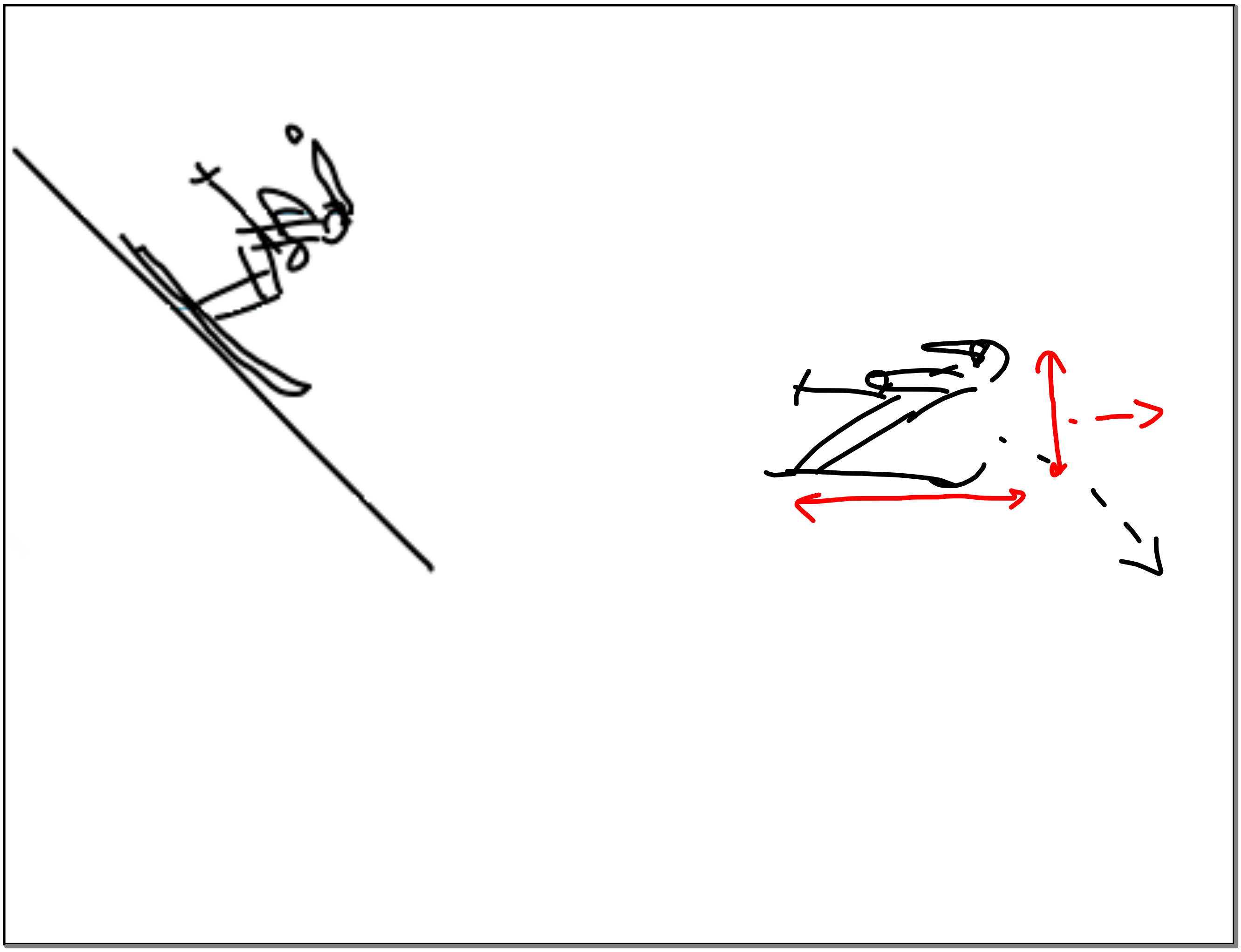
$$\sum F = ma$$

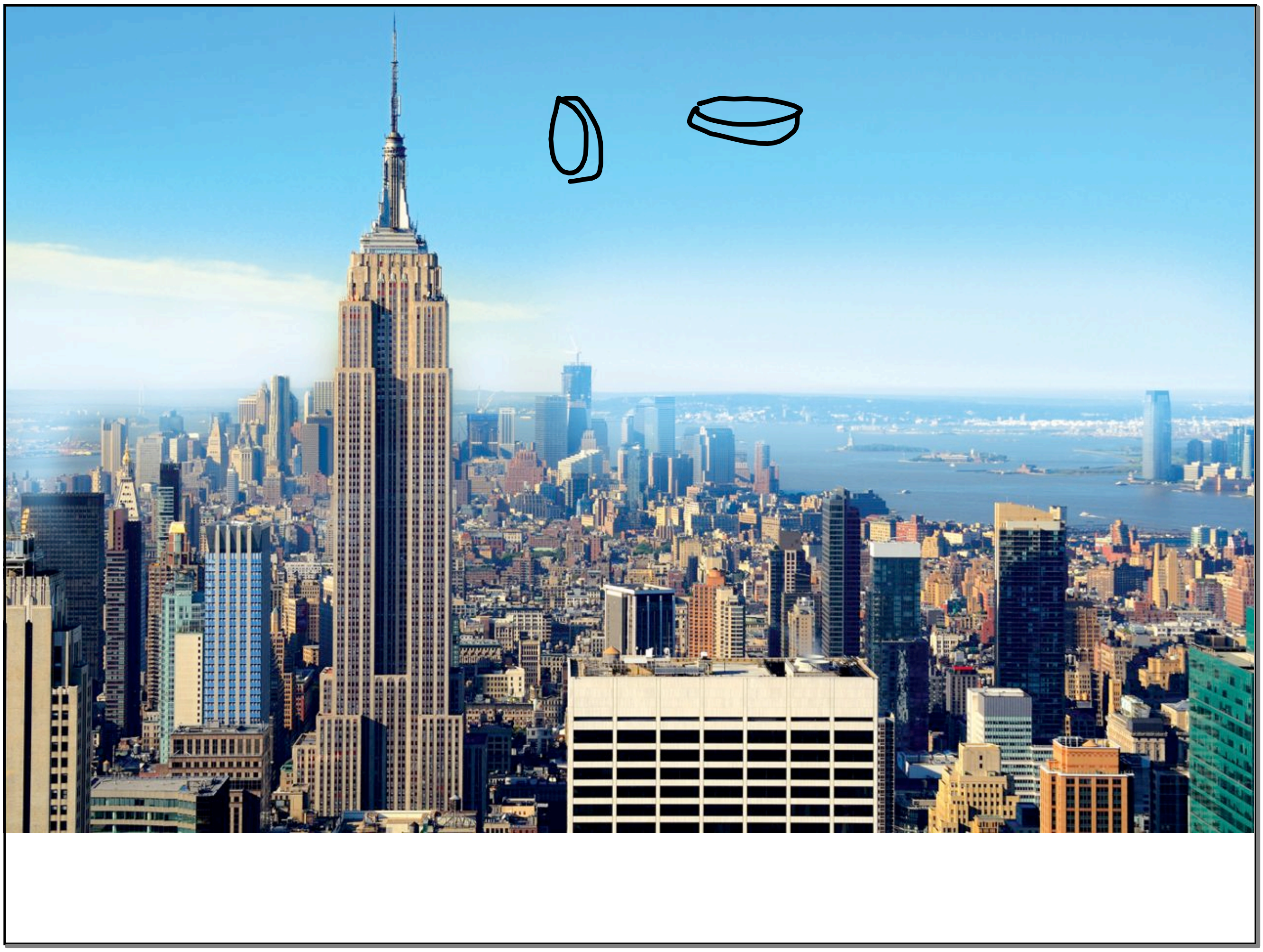
$$-10 = (1)a \qquad -100 = (10)a$$

With no drag, all things accelerate at 10 m/s/s downward,

because -10 will always be the ratio of weight to mass.

Another way to think about it: heavier things get a stronger pull of gravity, but they also have more mass which makes them tougher to accelerate. The two effects cancel out.





How do things fall when there is little or no drag?

→ a) They speed up.

b) They slow down.

c) They maintain constant speed.

If there is drag - what happens to it as you fall?

Remember: faster means more drag.

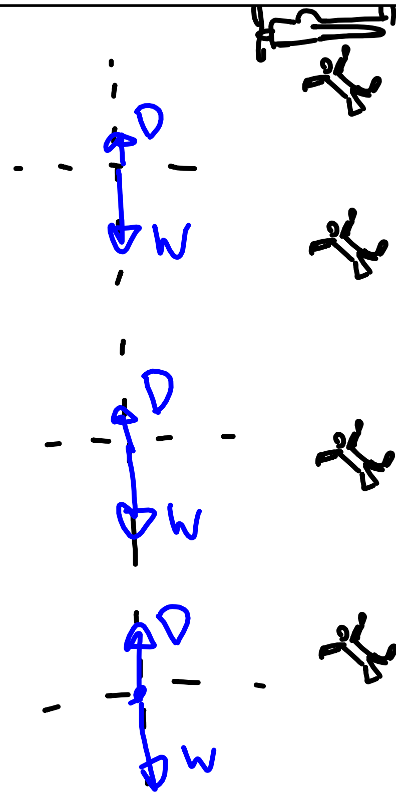
As you fall faster and faster,

drag gets stronger and stronger.

When it equals the weight, you

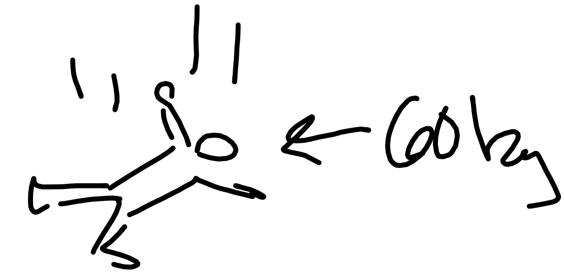
no longer accelerate.

$$\sum F = 0$$
$$\therefore a = 0$$



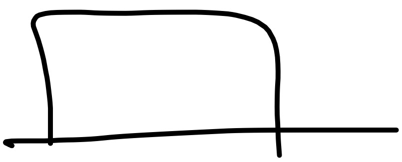
The velocity you reached is now your terminal (ending) velocity.

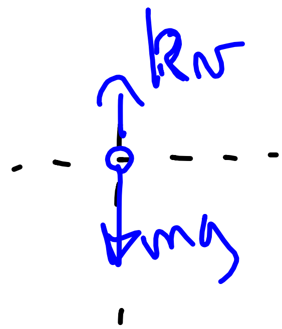
Find his terminal velocity



$$D = -kv$$

$$k = 10$$





at term. veloc. $a = 0$

$\therefore \sum F = 0$

$$D - W = 0$$

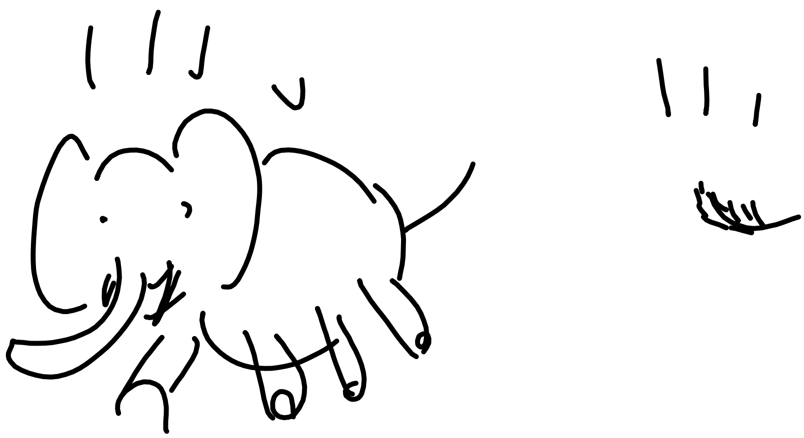
$$kv - mg = 0$$

$\vdots$

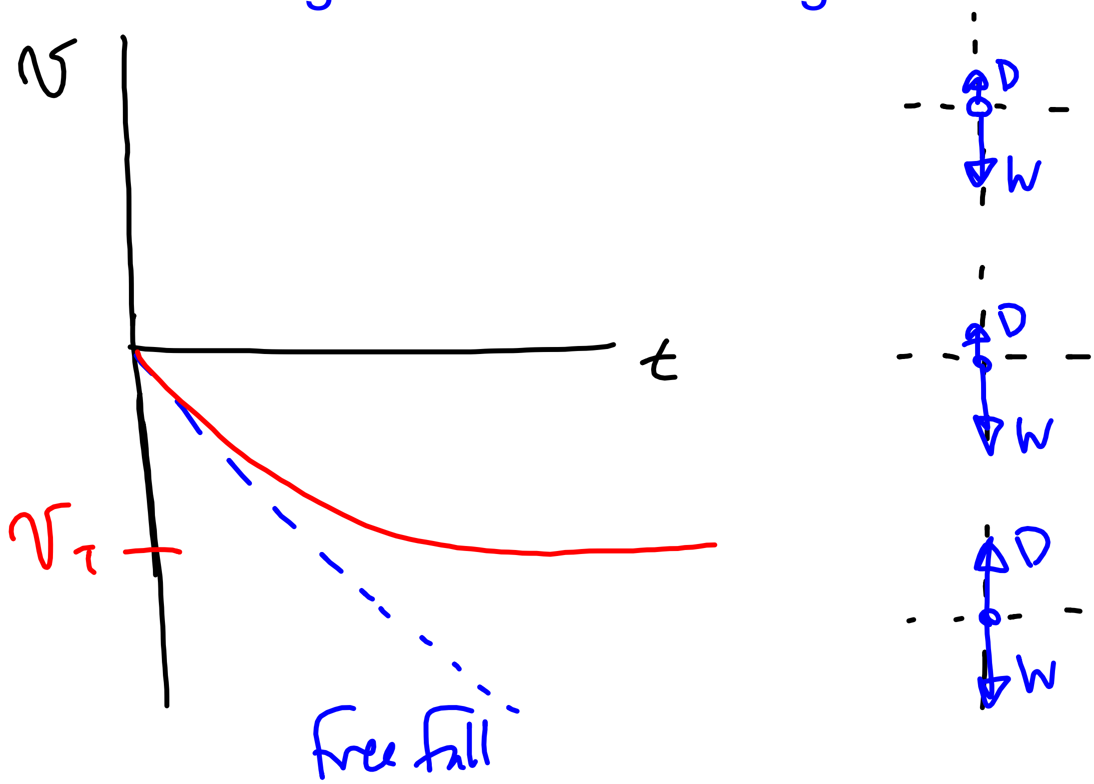
$$v = \frac{mg}{k} = \frac{(60)(10)}{(10)}$$

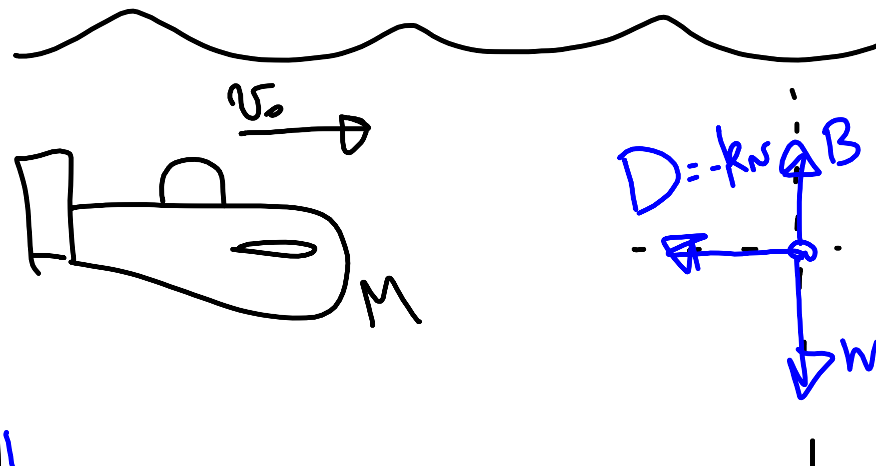
$$= 60 \, \frac{m}{s}$$

Which one experiences more drag?

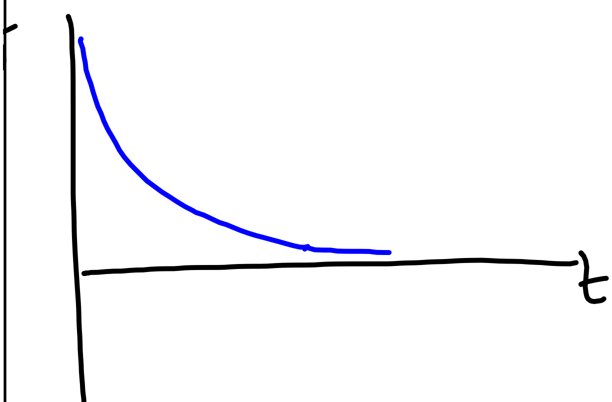


Falling from rest with drag.





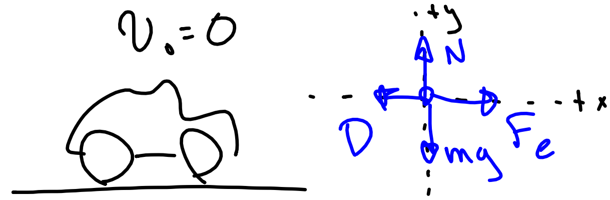
What is the initia
acceleration in t
of vo, M, and k?



$$\sum F_x = m a_x$$

$$-k v_0 = M a_x$$

$$-\frac{k v_0}{M} = a_x$$



The engine provides a constant force to the right of Fe. But there is also a drag force equal to -kv. The mass of the car is M.

a) Sketch the graph of the car's velocity over time.

b) What will the car's terminal velocity be? (In terms of k, M and Fe.)

c) What was the initial accel?

$$\sum F = ma$$

$$F_e - kv = Ma \quad (v \to 0)$$

$$F_e = Ma$$

$$\frac{F_e}{M} = a$$

$$\sum F = ma$$

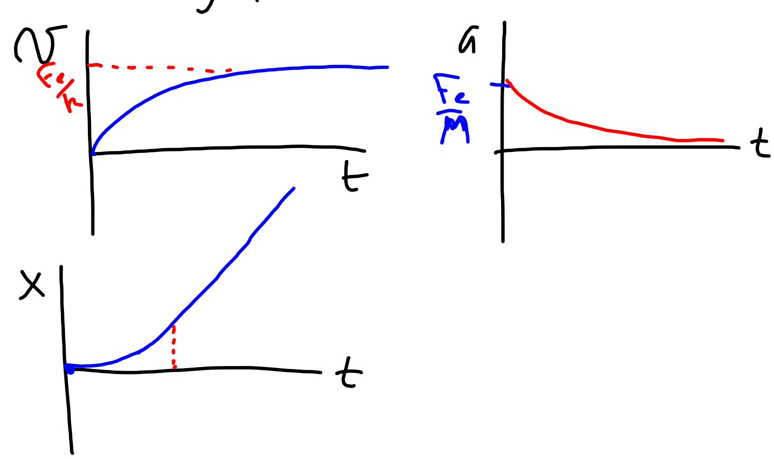
at term. v, $a = 0$

$$F_e - kv = 0$$

$$F_e = kv$$

$$\boxed{\frac{F_e}{k} = v}$$

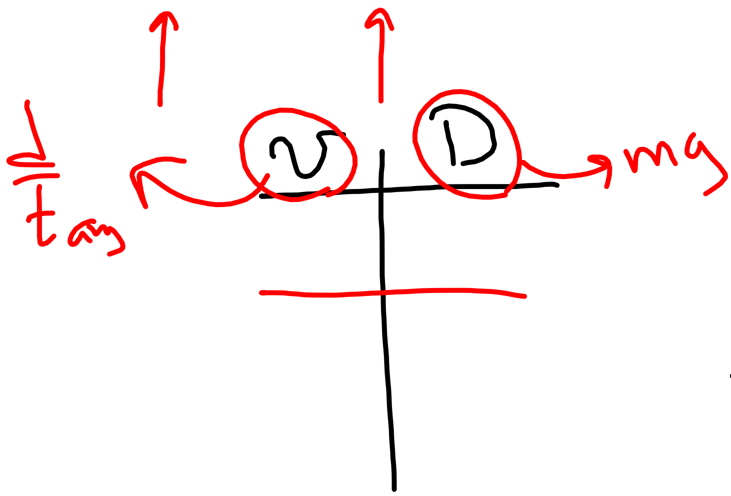
d) What does the accel vs. time graph look like?

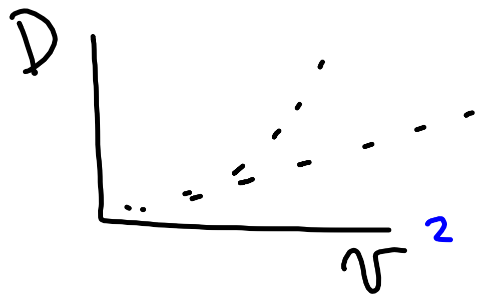


ACTIVITY : Find k for a coffee filter.

(Only checking calculations in excel & notebook.)

$D = -kv$ or $-kv^2$

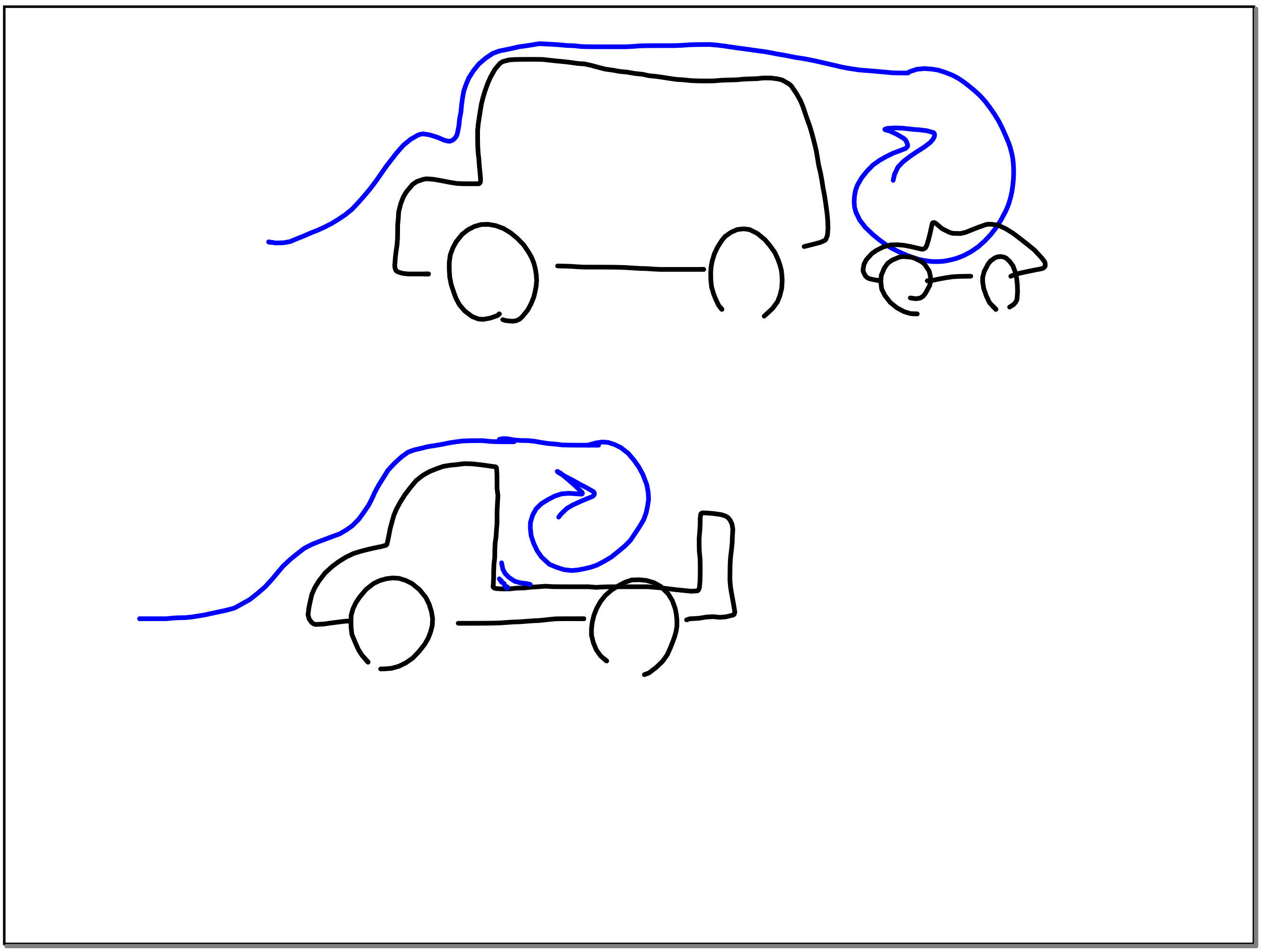




$D = kv^2$

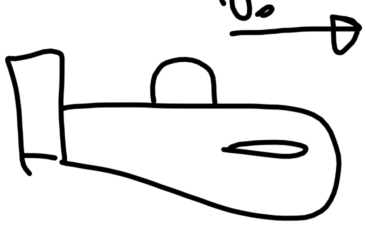
$y = 0.0055x$

$\therefore k = 0.0055$ units??



Drag FR Typical Questions

v_0



Only Drag acts

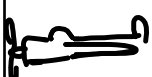
with an initial v

Initial accel?

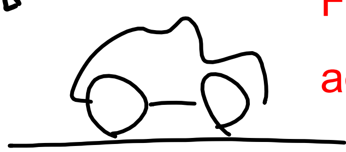
$\sum F = ma$; plug in v_0

Terminal v?

$\sum F = ma$; $a = 0$



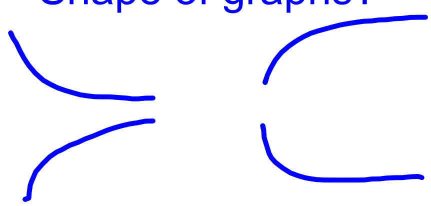
$v_0 = 0$



From rest, Drag builds

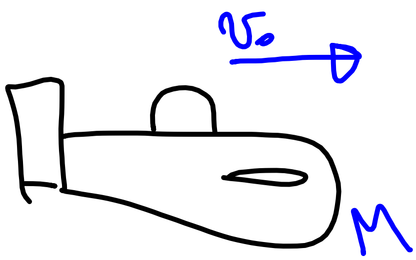
against const. Force

Shape of graphs?

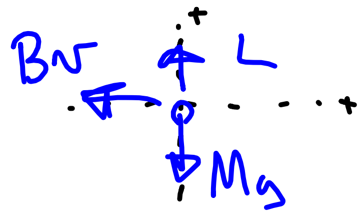


Differential Equations, Part 1

Setting up, but not solving



The submarine shuts off its engines and experiences a Drag force equal to -Bv.



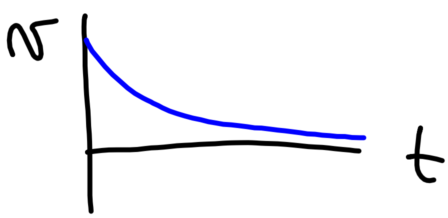
STEP 1:Write Newton's 2nd Law

$$\sum F = ma$$

STEP 2: Plug in the actual forces and actual variables

$$-Bv = Ma$$

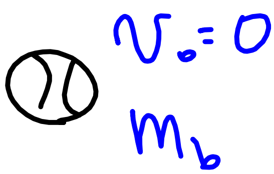
STEP 3: Rewrite a as the derivative of v



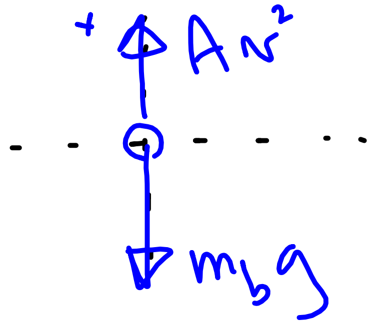
$$-Bv = M\left(\frac{dv}{dt}\right)$$

Differential Equations, Part 1

Setting up, but not solving



The ball falls from rest, and experiences a Drag force equal to $-Av^2$.



$$m_b g - Av^2 = -m_b\left(\frac{dv}{dt}\right)$$