Fluid Resistance

Fluid resistance is a friction force.

Properties of fluid resistance:

- acts in a direction opposite to the velocity of a moving object
- the magnitude depends on the speed of the object and is greater for an object moving at a greater speed.

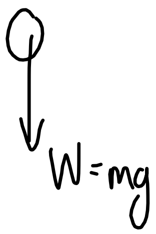
$$F_R \propto v^2$$

(doubling the speed increases F_R by a factor of 4)

- the magnitude also depends on the size (mass) and shape of the object. There is less air resistance on a small streamlined object.

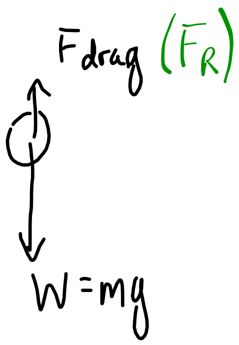
For a falling object with air resistance: (fluid)

Body Released from Rest



Weight is the only force acting. The acceleration is g.

Body Accelerates



($F_{drag} < W$)

Speed increases

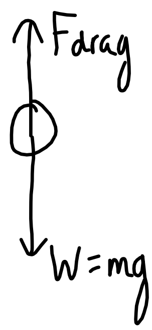
F_{drag} increases

F_{net} downward decreases

Acceleration decreases.

($a < g$)

Body at Terminal Velocity

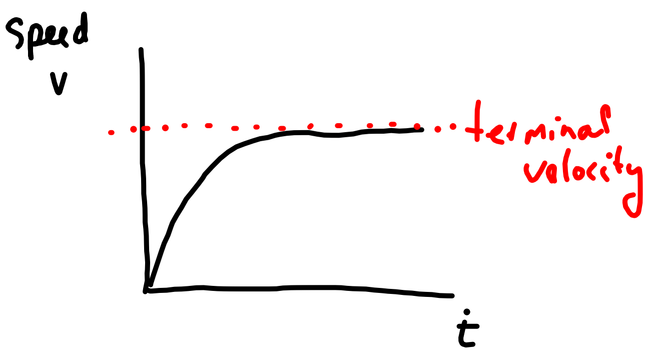


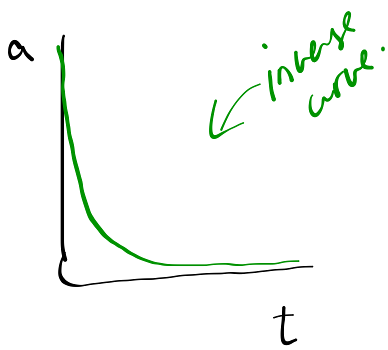
($F_{drag} = W$)

$F_{net} = 0$

acceleration is zero

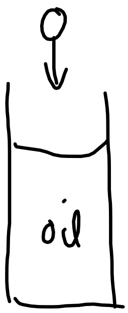
Terminal velocity



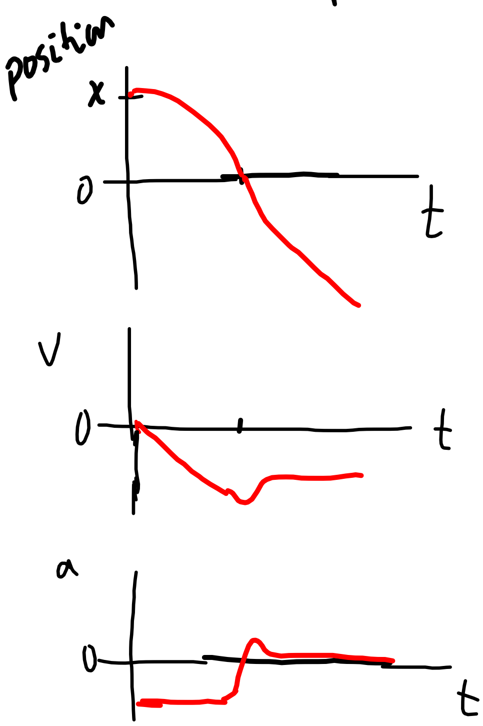


Example

A ball bearing is dropped from rest into oil from a small distance x above the oil. The ball bearing arrives at the surface of the oil above its terminal speed in the oil and subsequently slows to terminal speed as it falls through the oil.



Sketch position-t, v-t, a-t from the time the ball was released in air to the time its speed reduces to its terminal speed in oil



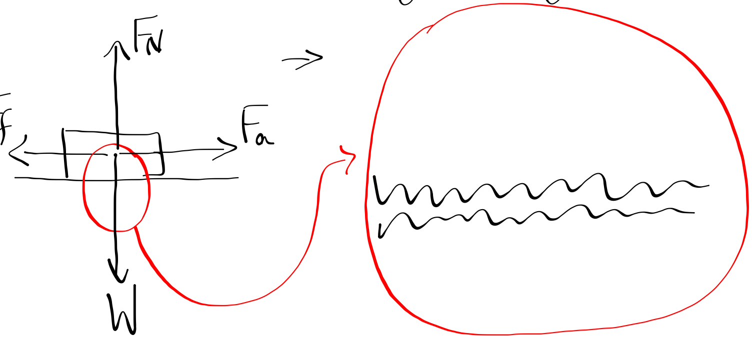
* take a position of zero to be the level of the liquid.

Friction

Static friction - the frictional force that you need to overcome in order to just start an object moving (can be zero up to a maximum)

(dynamic)
Kinetic friction - the frictional force that is experienced by a moving object.

FREE BODY DIAGRAM (FBD)



$F_f \propto F_N$

$$F_f = \mu F_N \implies$$ IB: $F_f = \mu R$

Where F_f is the frictional force (N)

F_N is the normal force (N) (always perpendicular to the surface)

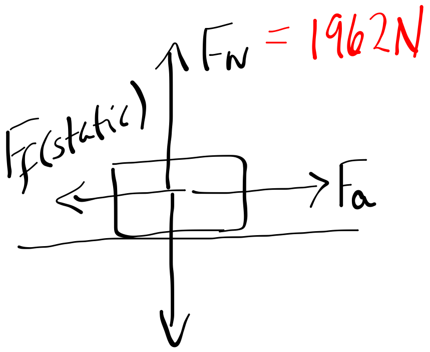
μ is the coefficient of friction. (depends on the surfaces)

MP|141

$m = 2.00 \times 10^2\ kg$

$F_f(static) = ?$

$\mu_s = 0.70$



$F_g = mg$

$F_g = (2.00 \times 10^2\ kg)(9.81\ m/s^2)$

$F_g = 1962N$

$F_f(static) = \mu_s F_N$

$F_f(static) = 0.70\ (1962N)$

$F_f(static) = 1.4 \times 10^3 N$

The additional force of static friction is $1.4 \times 10^3 N$

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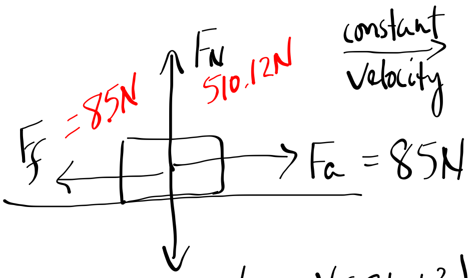
$m = 52\,kg$

constant velocity

$F_a = 85N$

$\mu_k = ?$



$F_g = (52kg)(9.81m/s^2)$

$F_g = 510.12N$

Vertically: $F_N = F_g$ (if F_a is horizontal and the surface is horizontal)

$F_N = 510.12N$

Horizontally: $F_f = F_a$ (constant velocity)

$F_f = 85N$

$$F_f = \mu F_N$$

$$\mu = \frac{F_f}{F_N}$$

$$\mu = \frac{85N}{510.12N}$$

$$\mu \doteq 0.17$$

TO DO

* PP|144 McGraw-Hill