Chapter 6 Force and Motion - II

- focus on the physics of 3 common types of force: frictional force, drag force, and centripetal force.

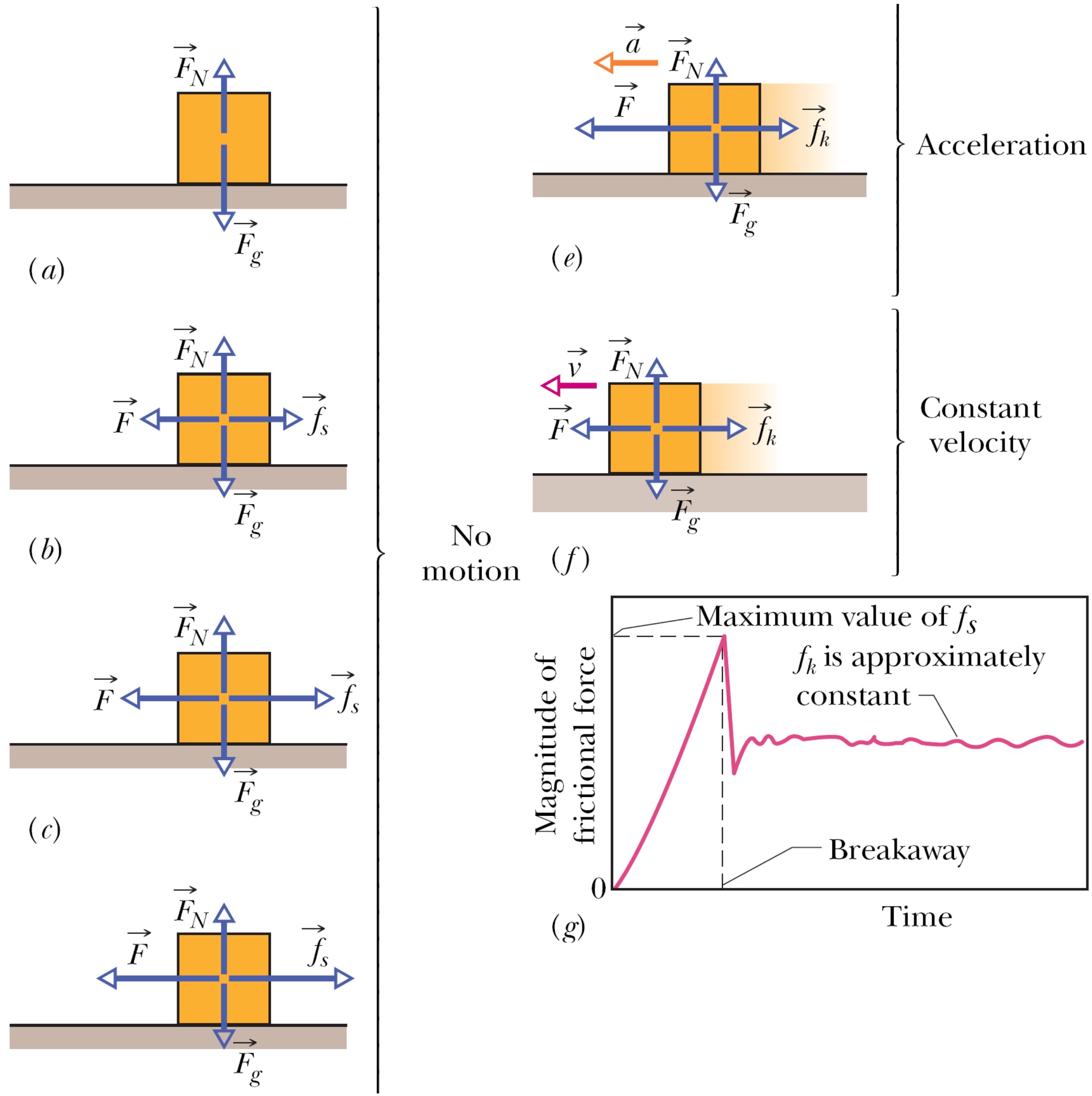
Friction

- a frictional force is, in essence, the vector sum of many forces acting between the surface atoms of one body and those of another body.

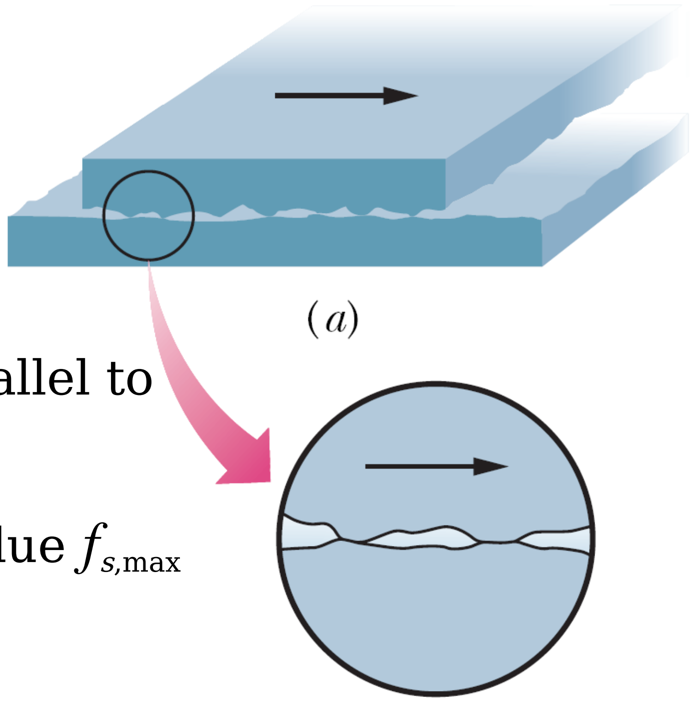
f_s: **static frictional force**

f_k: **kinetic frictional force**

$$f_k < f_{s,\max}$$



Properties of Friction



- For a force attempts to slide a body along a surface the resulting frictional force has 3 properties:

Property 1. If the body does not move, then the static frictional force and the component of force that is parallel to the surface balance each other.

Property 2. The magnitude of $\vec{f}_s$ has a maximum value $f_{s,\max}$ that is given by

$$f_{s,\max} = \mu_s F_N$$

where μ_s is the **coefficient of static friction** and f_N is the magnitude of the normal force on the body from the surface.

Property 3. If the body begins to slide along the surface, the magnitude of the frictional force rapidly decreases to a value f_k given by

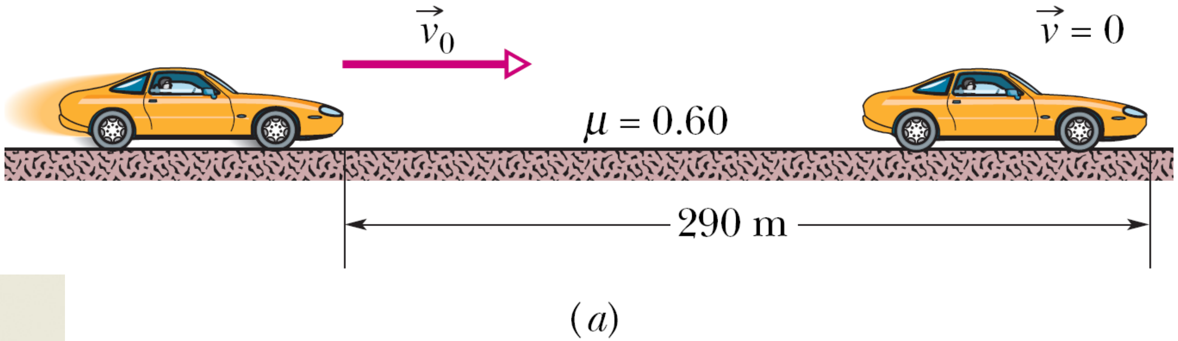
$$f_k = \mu_k F_N$$

where μ_k is the **coefficient of kinetic friction.**

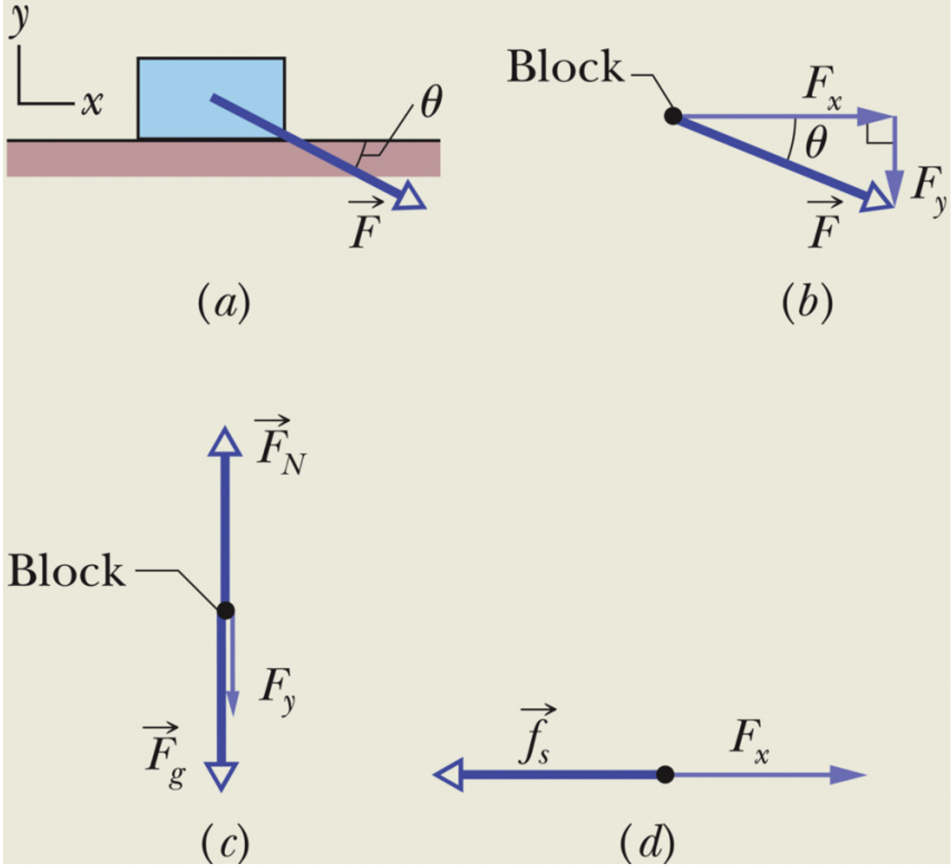
- notice the expressions are *not* vector equations.

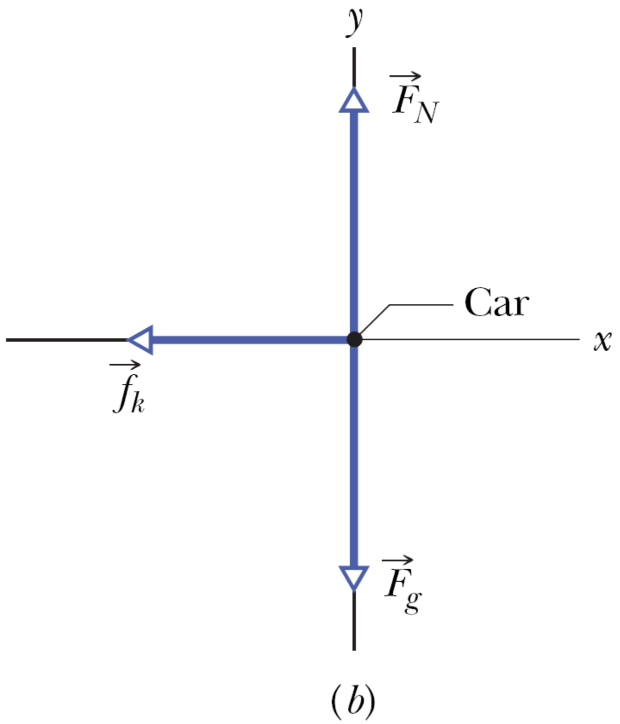
- The coefficients μ_s and μ_k are dimensionless and must be determined experimentally.

Problem 6-2



Problem 6-1





The Drag Force and Terminal Speed

- When there is a relative velocity between a fluid and a body, the body experiences a **drag force** that opposes the relative motion and points in the direction in which the fluid flows relative to the body.

- The magnitude of the drag force is related to the relative speed v by an experimentally determined **drag coefficient** C,

$$D = \frac{1}{2} C \rho A v^2$$

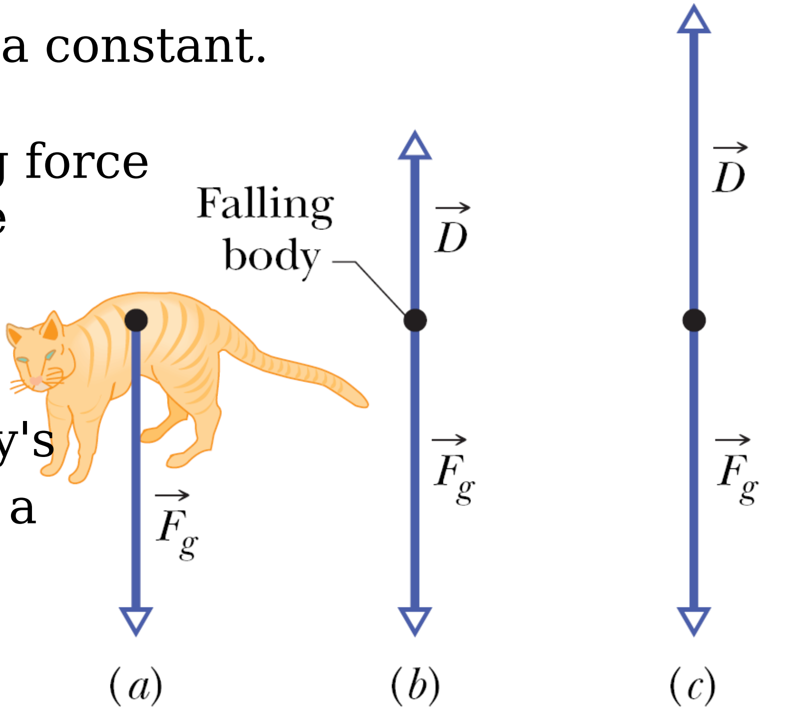
where ρ is the air density and A is the **effective cross-sectional area** of the body.

- The drag coefficient C (0.4 – 1.0) is usually not a constant.

- When a body falls from rest through air, the drag force is directed upward. The upward force opposes the downward gravitational force on the body,

$$D - F_g = m a$$

- If D eventually equals F_g, then a=0, and the body's speed no longer increases. Then body then falls at a constant speed, call the **terminal speed** v_t.



- To find v_t, we set a=0, then

$$\frac{1}{2} C \rho A v_t^2 - F_g = 0, \quad \text{give} \quad v_t = \sqrt{\frac{2 F_g}{C \rho A}}$$

Problem 6-3

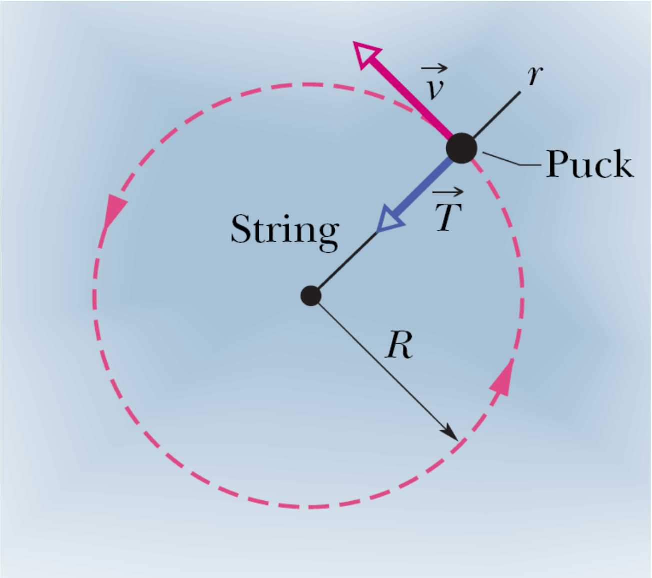
Uniform Circular Motion

- a body moves in a circle at constant speed v,

and the magnitude of its centripetal acceleration is

$$a = \frac{v^2}{R} \quad \text{centripetal acceleration}$$

where R is the radius of the circle.



- 2 examples of uniform circular motion:
  1. *Rounding a curve in a car*;
  2. *Orbiting Earth*.

A centripetal force accelerates a body by changing the direction of the body's velocity without changing the body's speed.

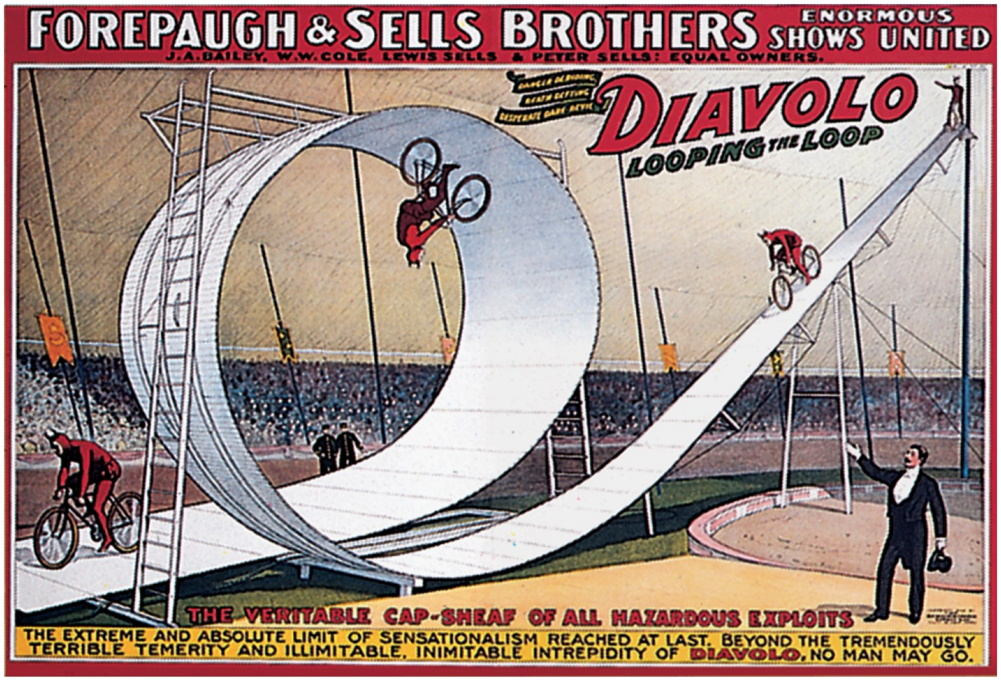
- Fro Newton's 2nd law the magnitude F of a centripetal force as

$$F = m \frac{v^2}{R} \quad \text{magnitude of centripetal force}$$

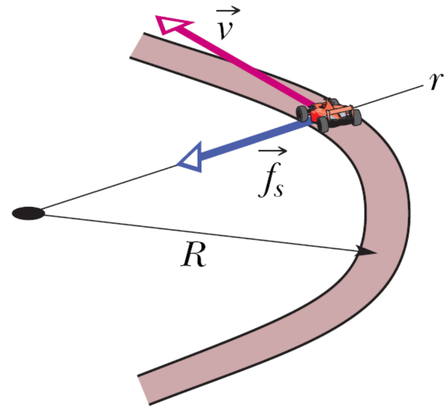
- The magnitudes of the acceleration and the force are constant, but the directions are not.

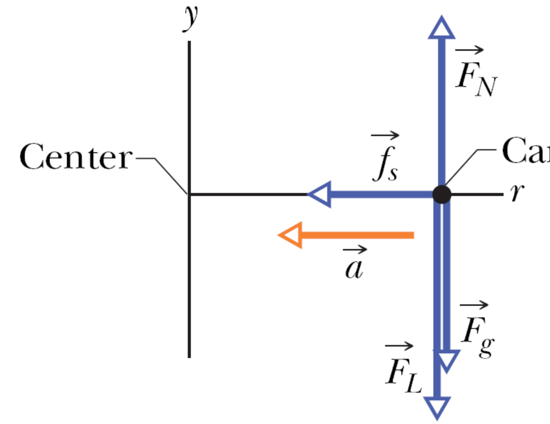
Problem 6-4

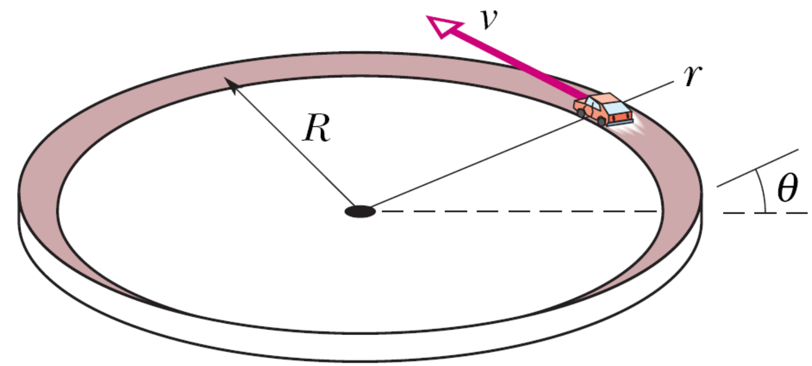
Problem 6-5

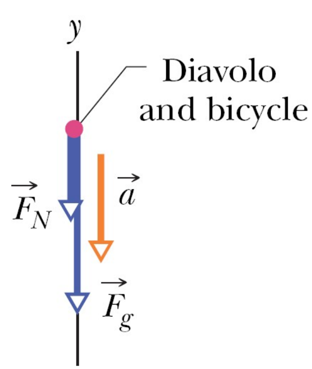


(a)

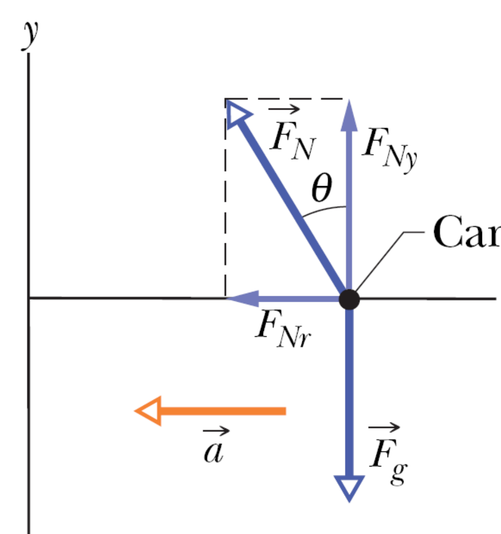




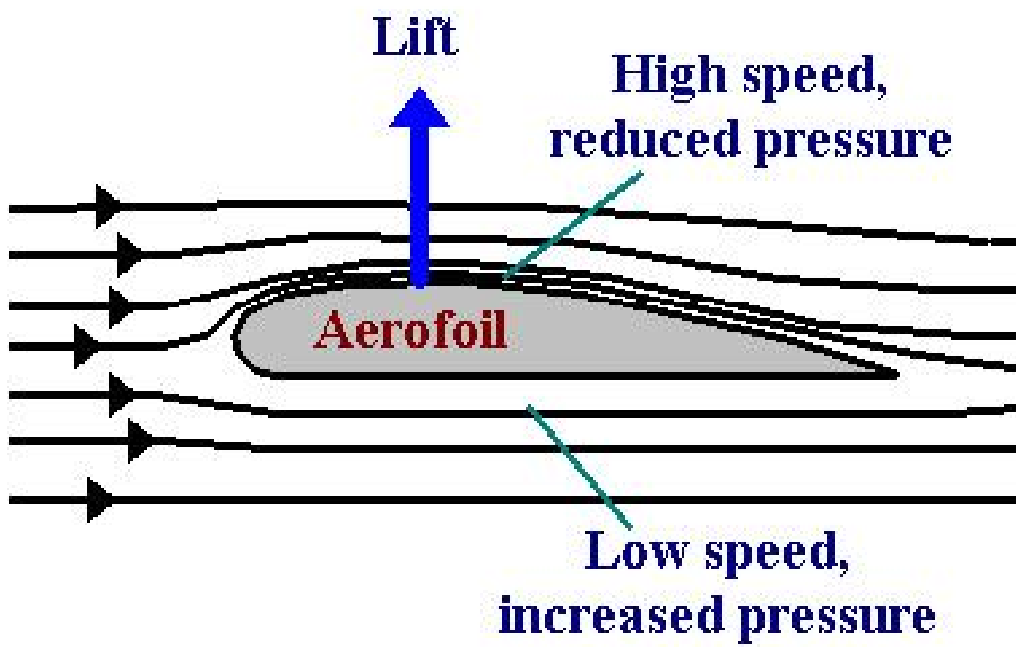


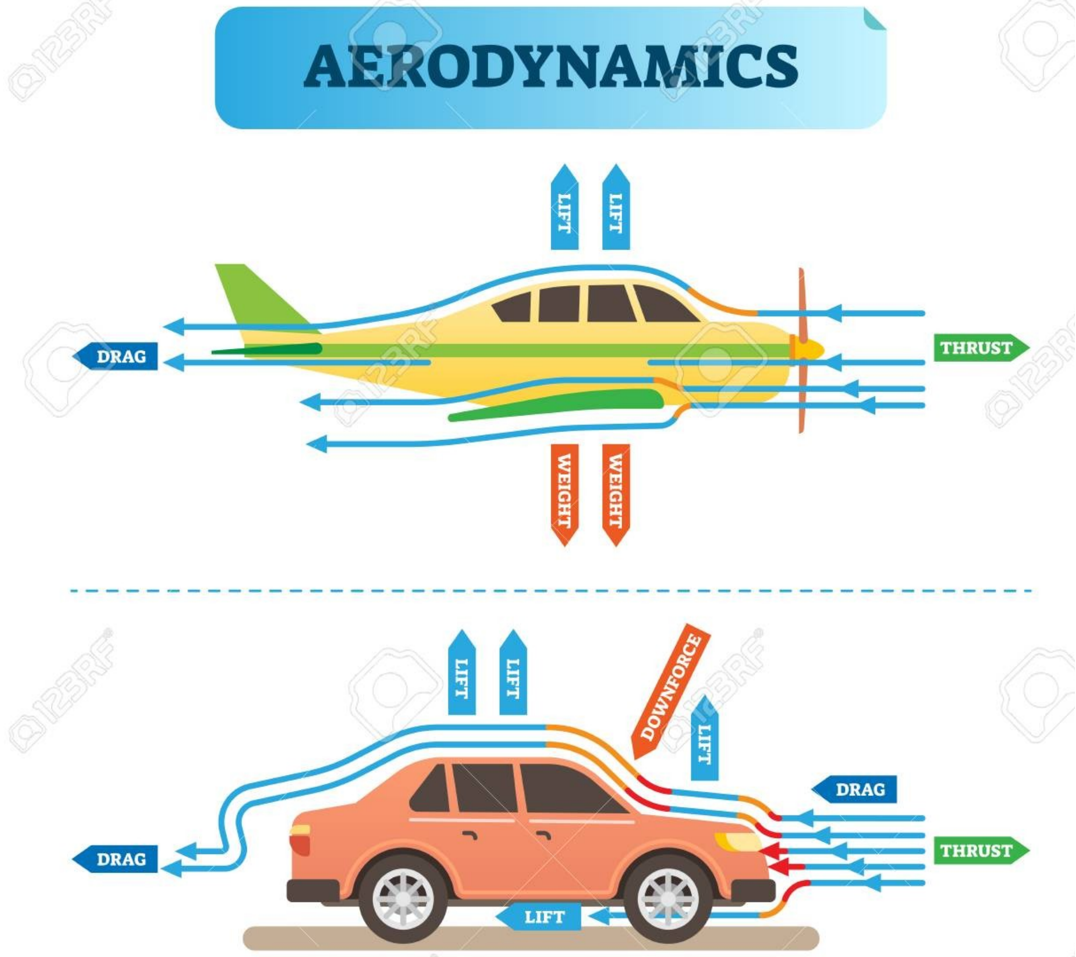


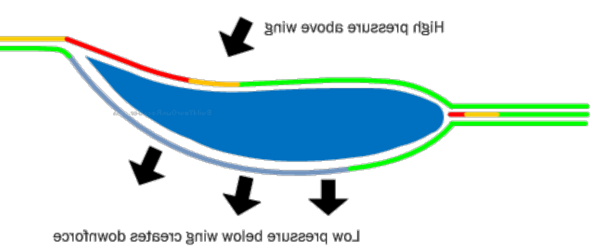
Problem 6-6

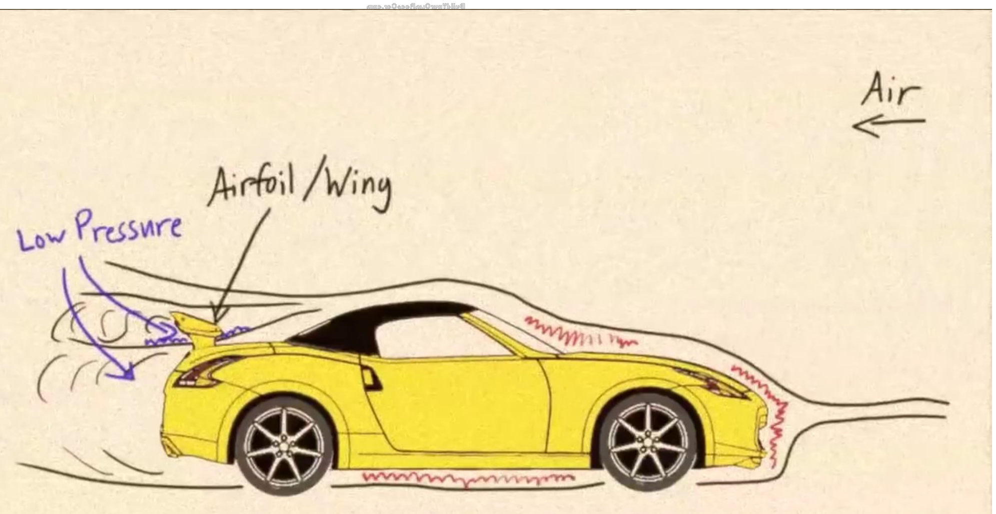


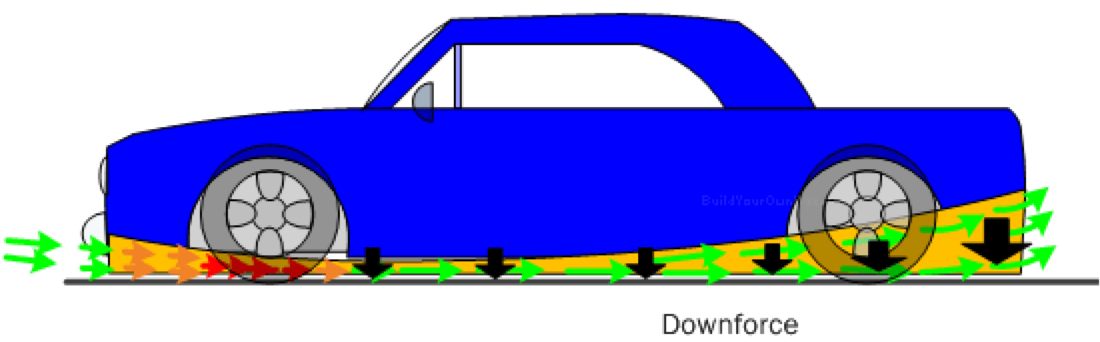
The chosen problems: 28, 34, 59


Lift
High speed,
reduced pressure
Aerofoil
Low speed,
increased pressure


AERODYNAMICS
LIFT
LIFT
DRAG
THRUST
WEIGHT
WEIGHT
LIFT
LIFT
DOWNFORCE
LIFT
DRAG
DRAG
THRUST
LIFT


High pressure above wing
Low pressure below wing creates downforce


Air
Airfoil / Wing
Low Pressure


Downforce