Musical Acoustics

Lecture 3

Physical Quantities - II

Force and Acceleration

Isaac Newton

❑ Experimentally, we find if there is a net force applied to an object, it accelerates.

❑ We also find that the ***acceleration (a)*** is ***directly proportional*** to the ***applied force (F)*** and ***inversely proportional to the mass (m).*** That is:

$$a = F / m$$

This means:

➢ Increasing the force increases the acceleration; decreasing the force results in a lower acceleration.

This is Newton's Law, and it is often written:

$$F = ma$$

Force

Some examples of forces

- ✓ Gravitational
- ✓ Electric
- ✓ Magnetic
- ✓ Friction
- ✓ Wind drag
- ✓ Forces in a compressed or stretched spring

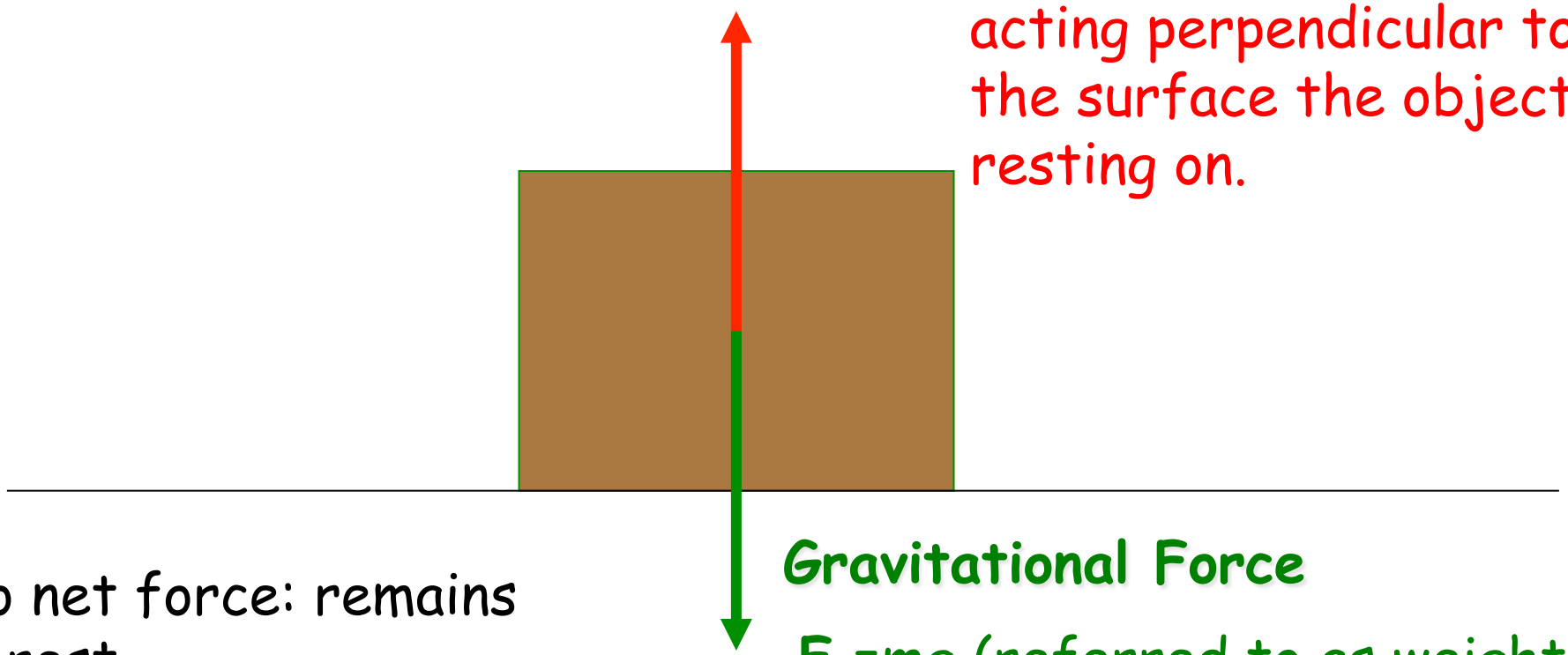
The weight of any object on the Earth is the gravitational force exerted on it by the Earth:

$$F_g = mg$$

Note: .

- *Weight* ***is not*** *the same as mass.*
- Do not confuse g = gram with g = 9.8 m/s^2 = acceleration due to gravity
- Unit of force: *Newton* (N): 1 N = 1 kg m/s^2

Gravitation and Normal Forces



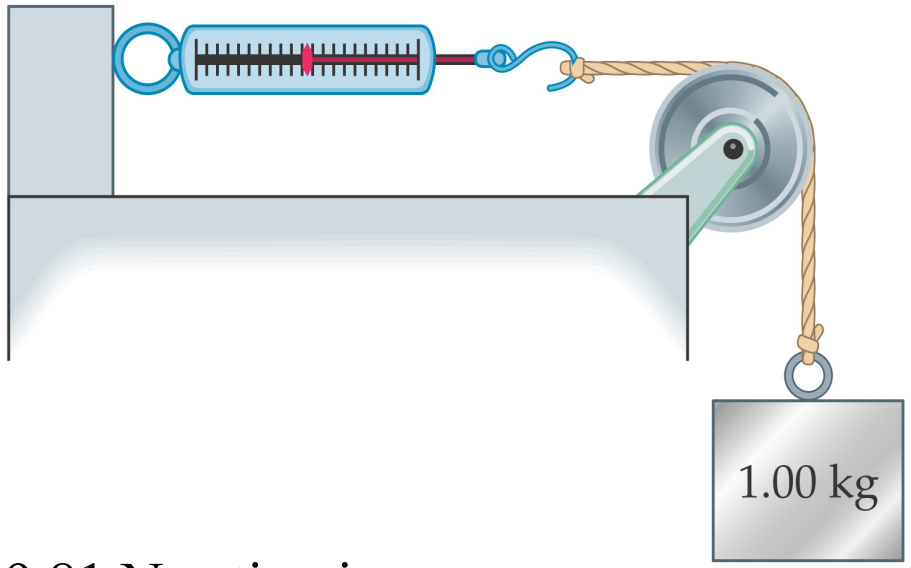
Normal Force: force acting perpendicular to the surface the object is resting on.

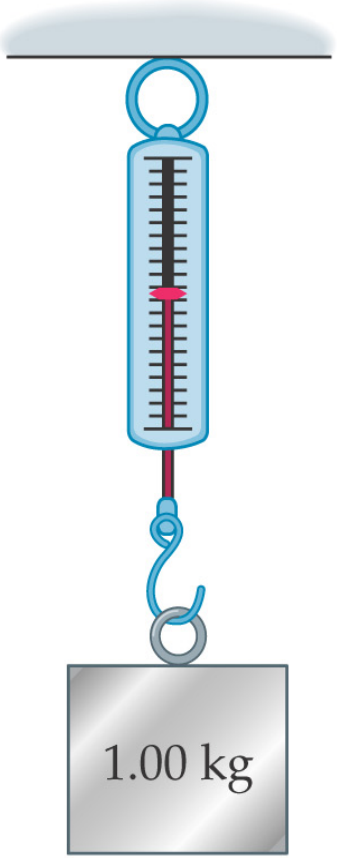
Gravitational Force

F_g=mg (referred to as weight)
g=9.81 m/s^2

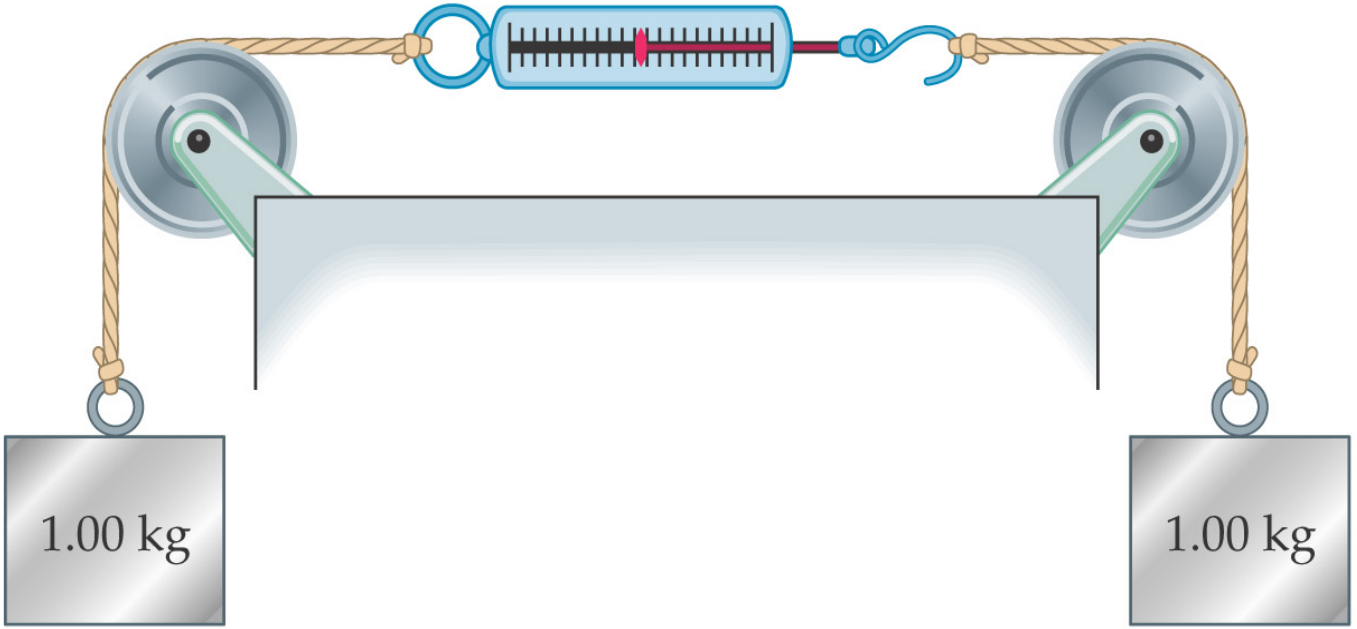
1. No net force: remains at rest.
2. $F_{mass\text{-}ground} = -F_{ground\text{-}mass}$

Each Spring-Scale reads 9.81 N !!!

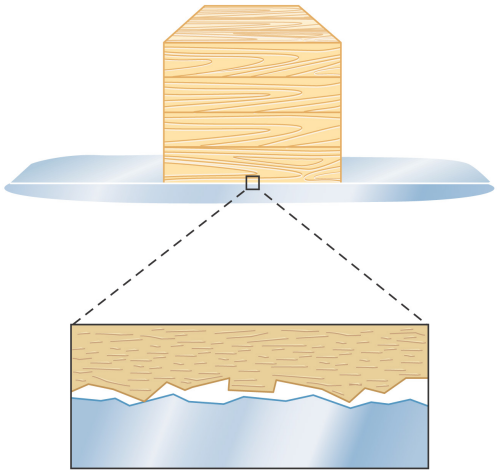




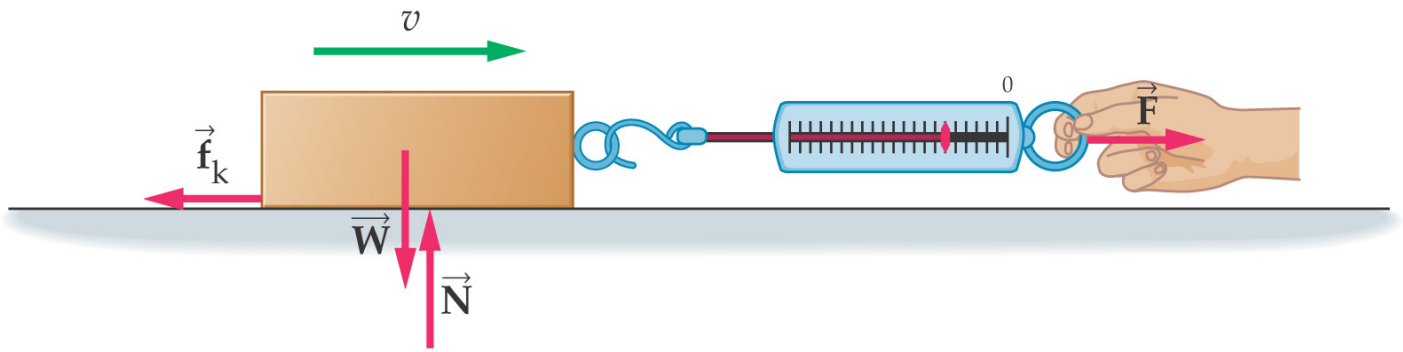
Each Scale has two forces of 9.81 N acting in opposite directions on its two ends → zero N.



Friction

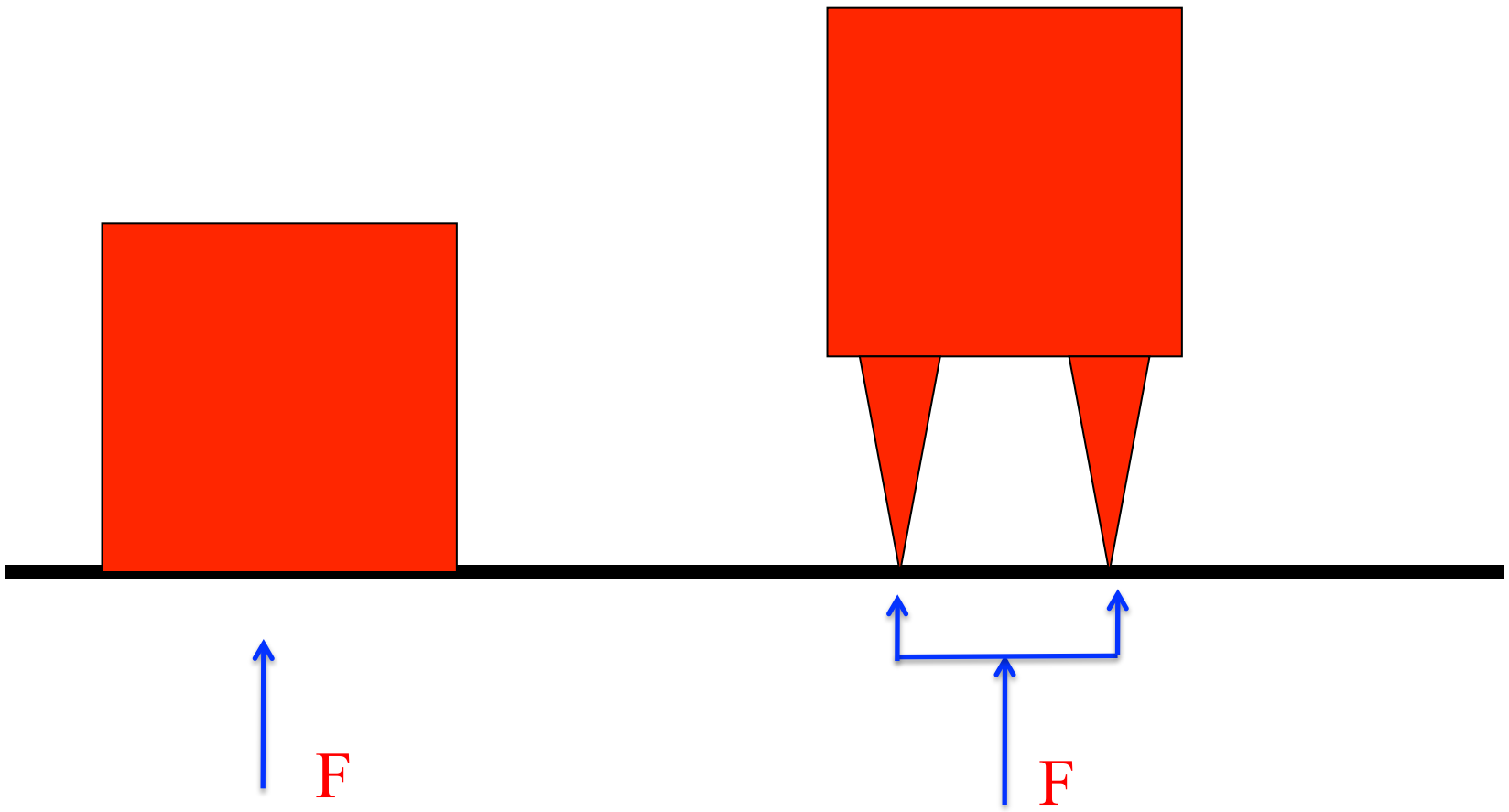


- As a block slides on the table, the force from the surface of the table acting on the bottom of the block has components both perpendicular to the surface, and parallel to the surface.
  - The component perpendicular to the surface we call the Normal force, N.
  - The component parallel to the surface is **friction, f**.



Pressure (Force per Area)

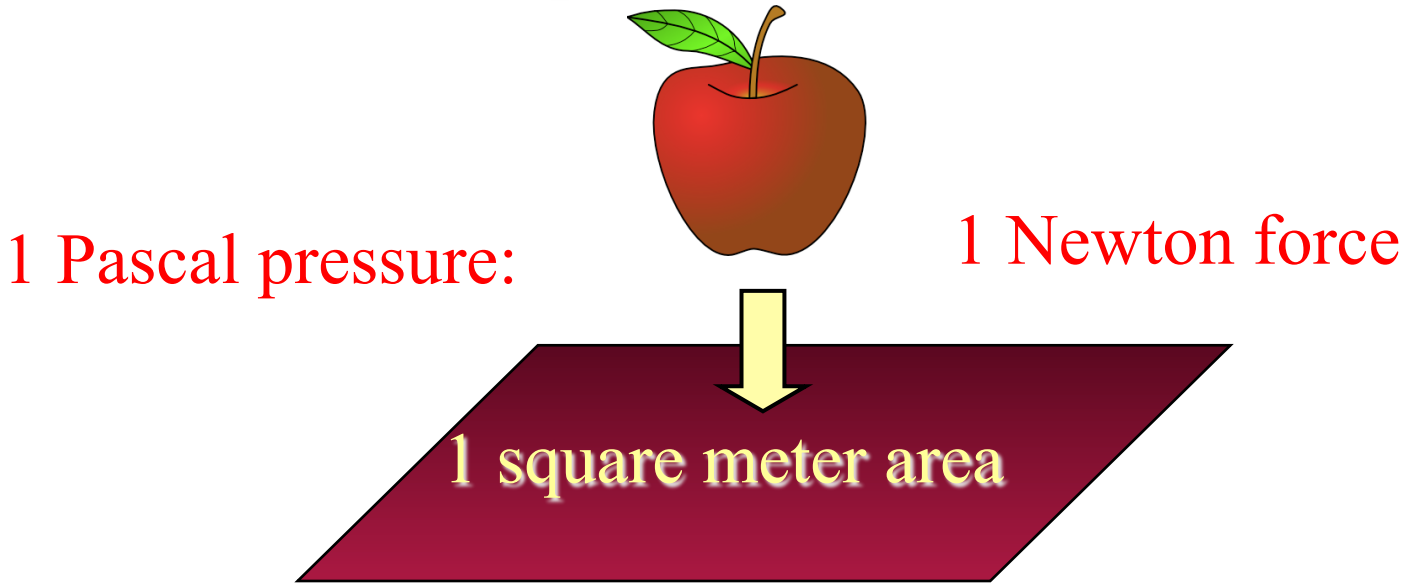
Pressure = F/A (**N/m^2=Pa**)



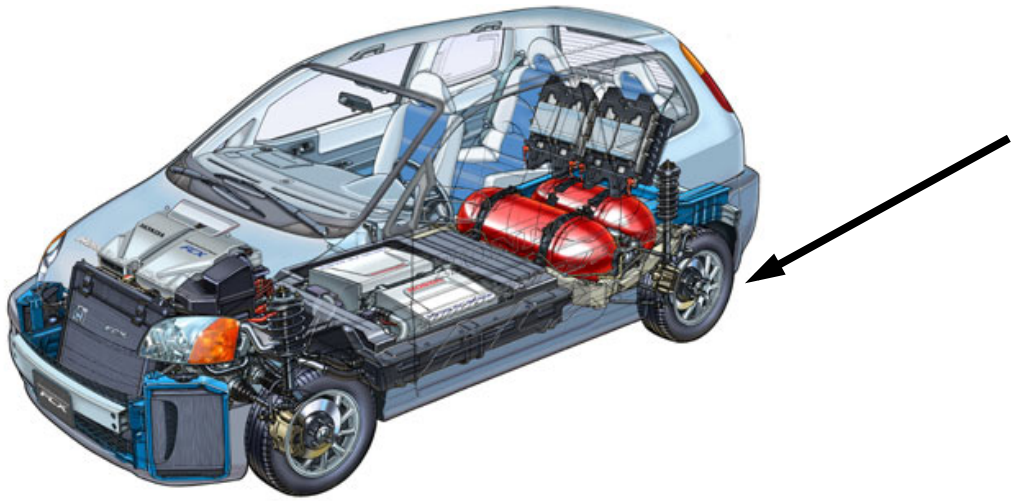
Same force, different pressure

The unit of pressure in SI units is the

Pascal [Pa] = 1 Newton/ m^2



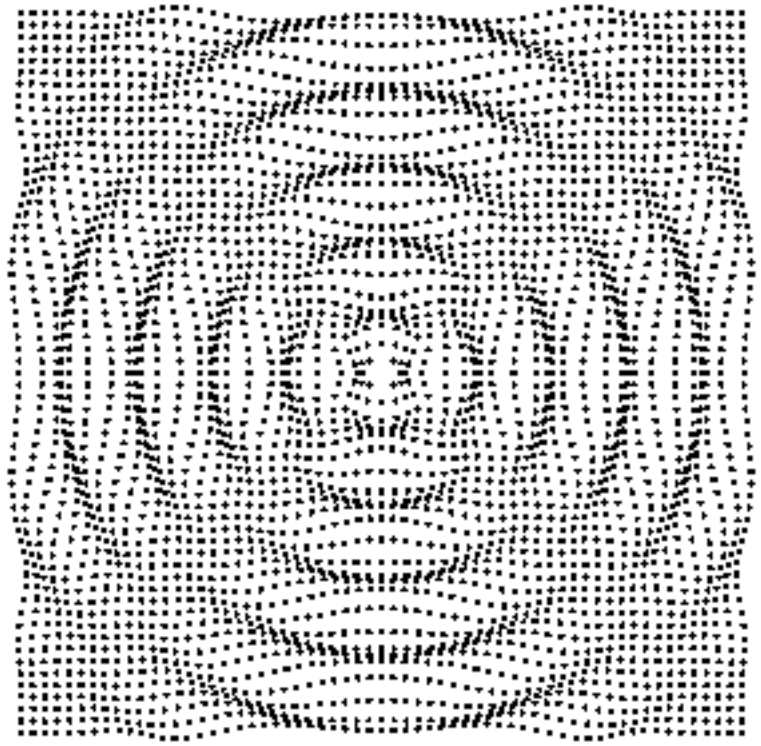
Standard atmosphere = 1.0 atm = 101 kPa = 14.7 psi



Tire pressure

A few 100 kPa

Sound



- Sound is a **variation of pressure in air**

- Threshold of hearing = 2×10^{-5} Pa

- Threshold of painful sound = 20 Pa

- Atmospheric pressure = 100,000 Pa ! (how can the ear withstand that?)

Energy

1. Energy of motion (kinetic energy)

2. Heat

3. Electricity

4. Waves - like ocean waves, sound waves, etc

5. Chemical

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Conversion of Energy

- Falling object converts gravitational potential energy into kinetic energy
- Friction converts kinetic energy into vibrational (thermal) energy
- Energy is conserved
- Kinetic energy is proportional to v^2… (in fact, $K = \frac{1}{2} mv^2$)
- Heat is a form of energy
  - just randomized kinetic energy on micro scale
  - is a product of friction, many chemical, electrical processes

Energy Conservation Example

- Roller coaster car lifted to initial height (energy in)
- Converts gravitational potential energy to motion
- Fastest at bottom of track
- Re-converts kinetic energy back into potential as it climbs the next hill

Power

- Power is energy exchanged per unit time (Watts = Joules/sec)
- One horsepower = 745 W
- Perform 100 J of work in 1 s = 100 W
- Run upstairs, raising your 70 kg (700 N) in 3 seconds → 700 W output.
- A rocket puts out a few GW (gigawatts, or 10^9 W) of power.