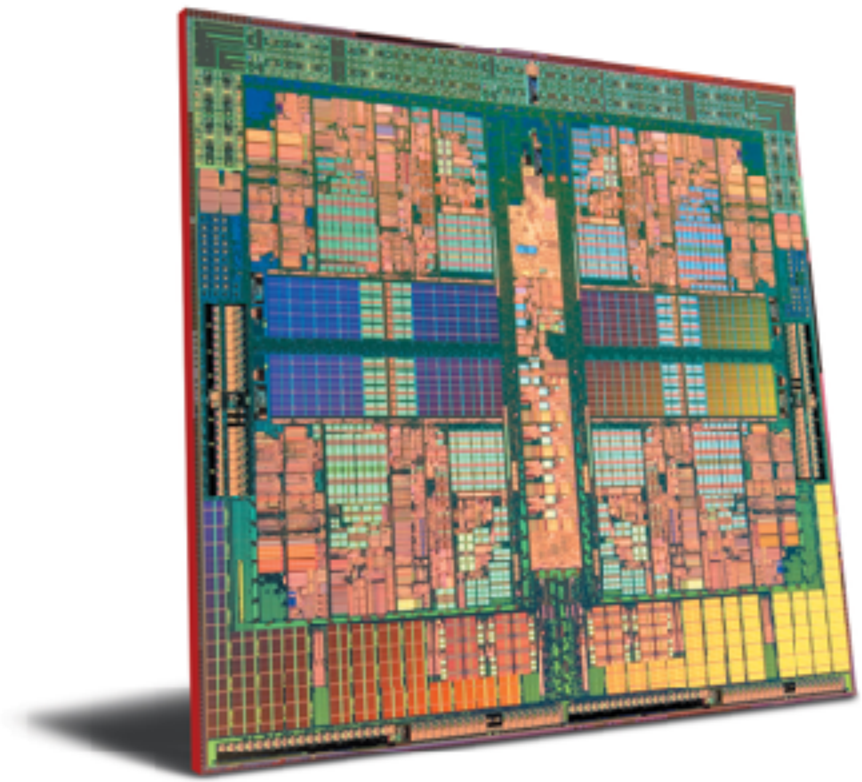

Kinetic Energy
Energy
ITP / NYU / Feddersen

Humans move things

moving rocks



moving electrons

To get anything moving, we need to exert a force.

Newton's second law:

Force = mass * acceleration

(F = ma)

so also

acceleration = force / mass

SI Units:

1 Newton force = 1 kg mass * 1 m/s/s acceleration

Note:

- "Lbs" or "pounds mass" is mass in English measure
- "Pounds force" is force in English measure

From google (you can type in equations and google handles the units):

(1 kg) * 1 ((meter / second) / second) = 1 newton

This leads to definitions for energy and work in physics:

Work is done when a force is applied through a distance. **Energy** is evidenced by the **capacity for doing work**. So:

Energy = force * distance

SI Units:

1 **Joule** *energy* = 1 Newton *force* * 1 Meter *distance*

(Since a newton is a unit of force, and F=ma, we can reduce this to:

1 joule = kg * 1 m / s / s * 1 m)

(1 newton) * 1 meter = 1 joule

((1 kg) * (1 (m^2))) / (1 (s^2)) = 1 joule

Power is the rate of work.

Power = Energy / Time

SI Units:

1 **Watt** power = 1 Joule energy / 1 second time

so also

1 Joule = 1 Watt * 1 second

(1 joule) / (1 second) = 1 watt

We can perform work against the force of gravity to store energy in the position of objects in a gravitational field.

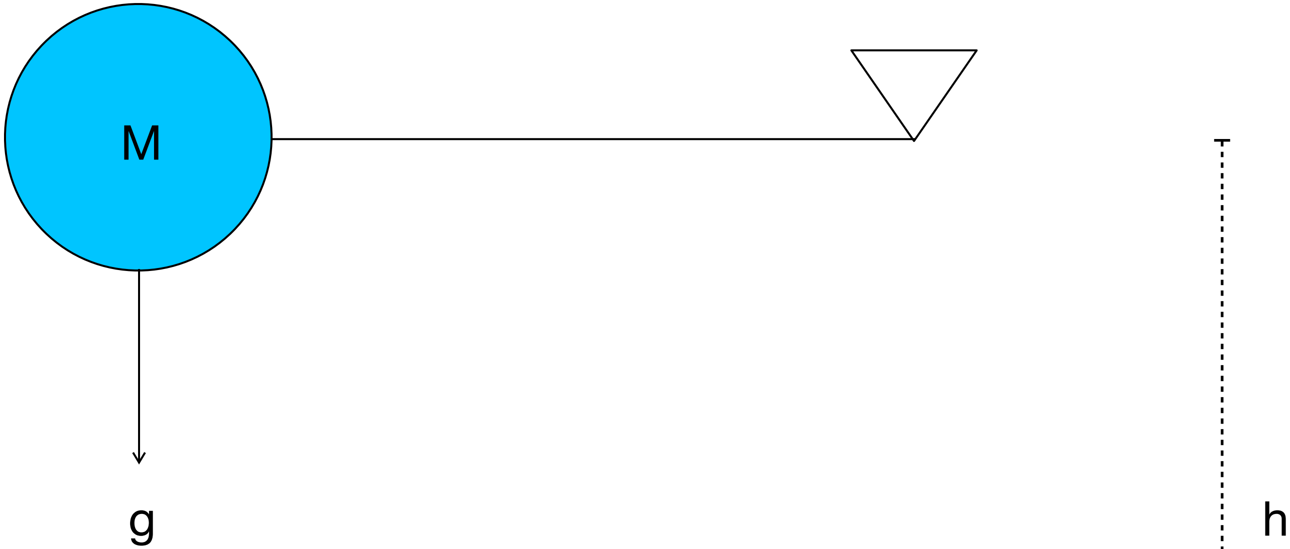
Gravitational Potential Energy = mgh

m = mass
g = gravitational acceleration = 9.8 m/s/s
h = height

Google Calculator handles units!

(1 kg) * (9.8 ((m / s) / s)) * (1 meter) = 9.8 joules

Note: 9.8 is pretty close to 10! Rounding makes the math easy.



PE = mgh

(9.8 is pretty close to 10...)

example:

(10 kg) * (9.8 (m / (s^2))) * (1 m) =

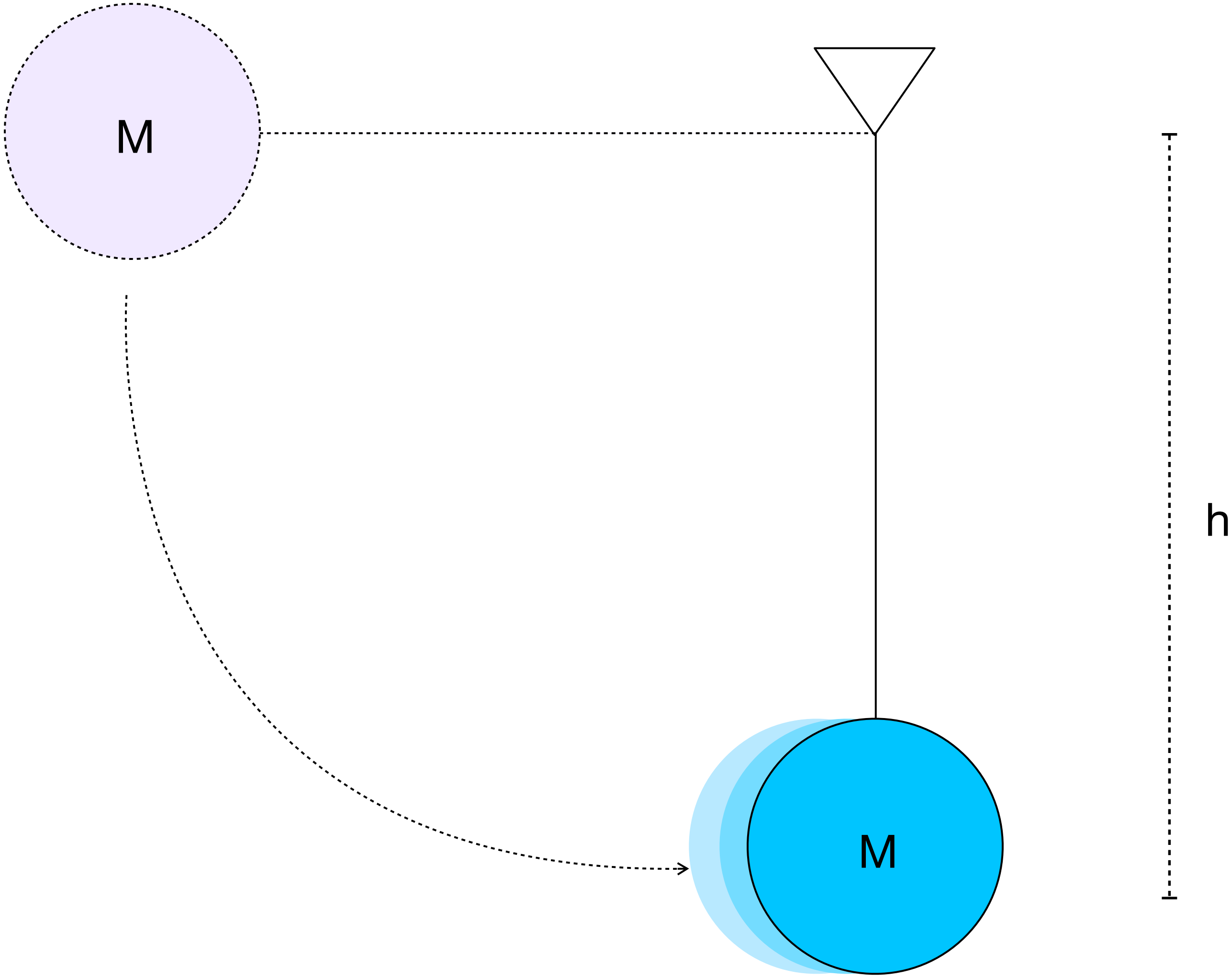
98 joules

Kinetic energy is the energy of objects in motion:

$$\textbf{Kinetic Energy} = \tfrac{1}{2} mv^2$$

m = mass in kg
v = velocity in meters/second

(1 / 2) * (1 kg) * ((1 (m / s))^2) = 0.5 joules

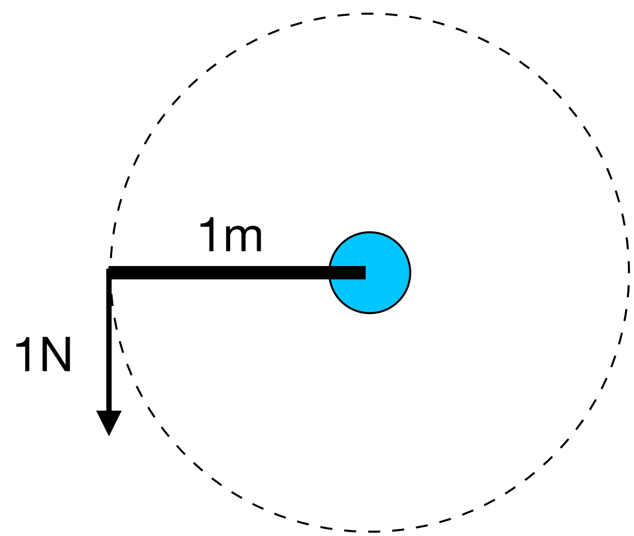


$KE = \frac{1}{2} mv^2$

Rotational Work

Same as linear work, but the force is traveling in a circle.

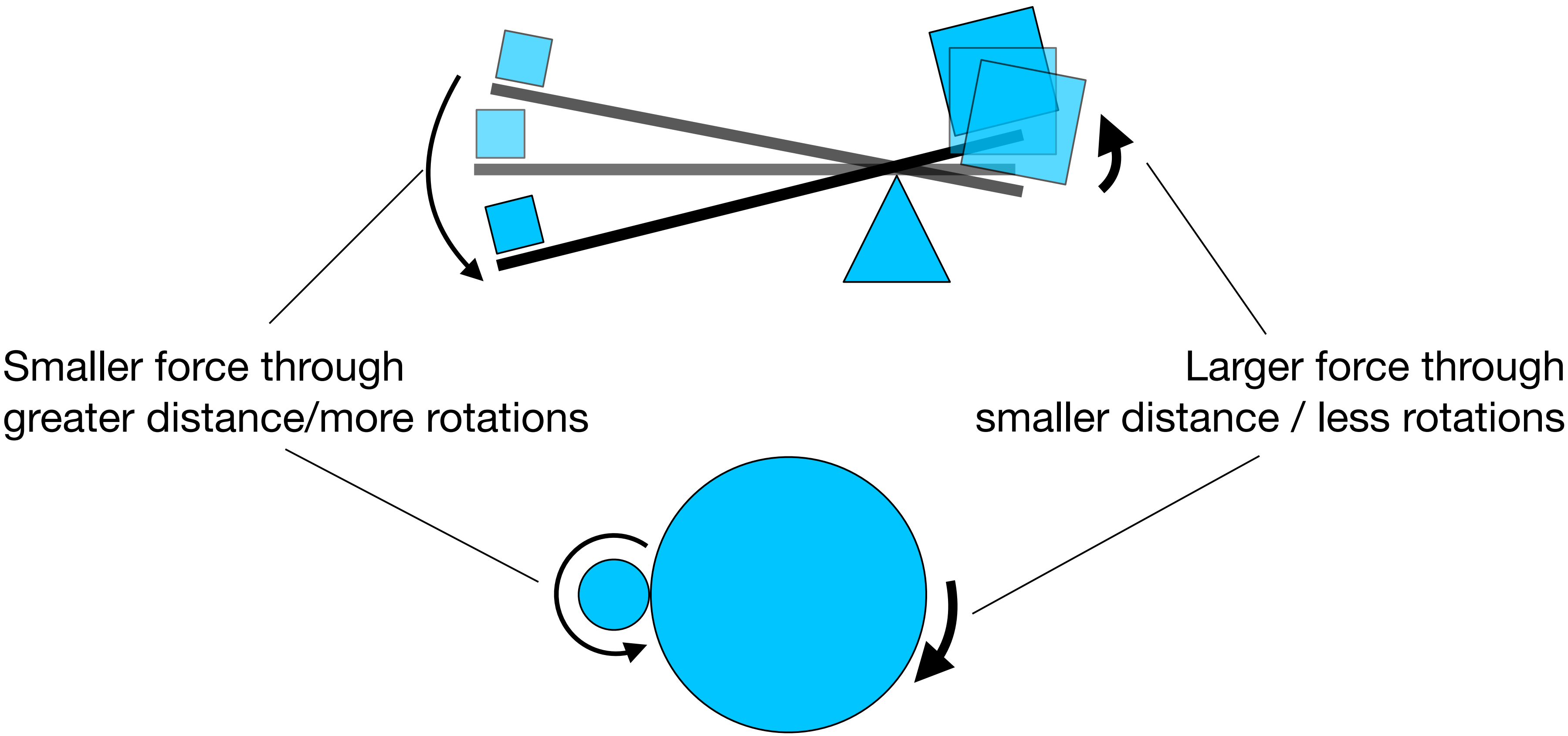
So 1 Newton force applied to a 1 meter lever pushed through 360 degrees = 6.28 Joules work (The force moves through the circumference of the circle = 2 pi meters)



(1 newton) * 1 meter * (360 degrees) = 6.28318531 joules

Mechanics

Levers, gears, and other mechanisms let us **trade off distance** and **force** to best suit an application.

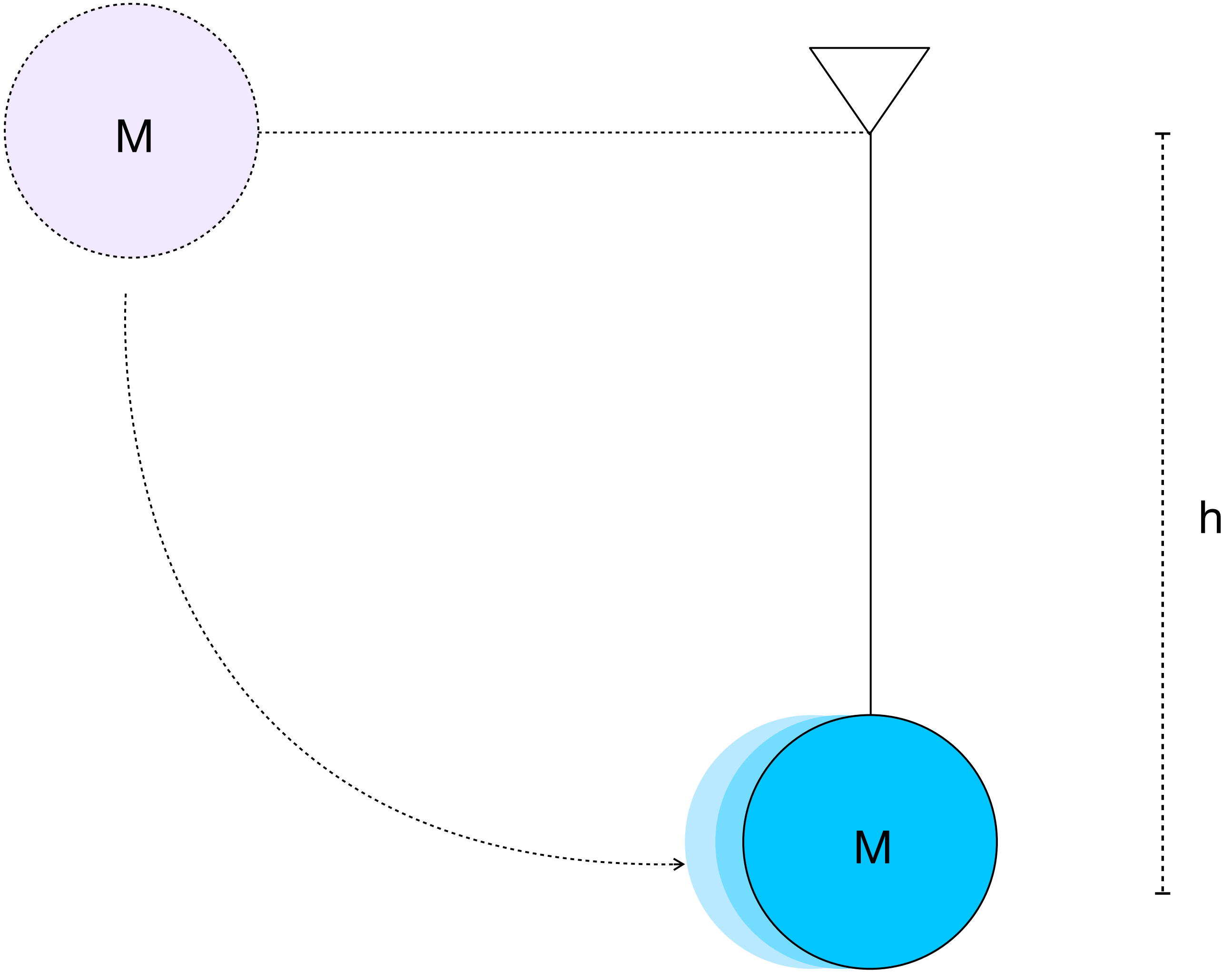


Thermodynamics:

We can't get work out of a system that isn't in the system in the first place.

aka 1st law, "*Conservation of energy*"

aka "You can't win"



On first swing, from 1st Law we can guess that:

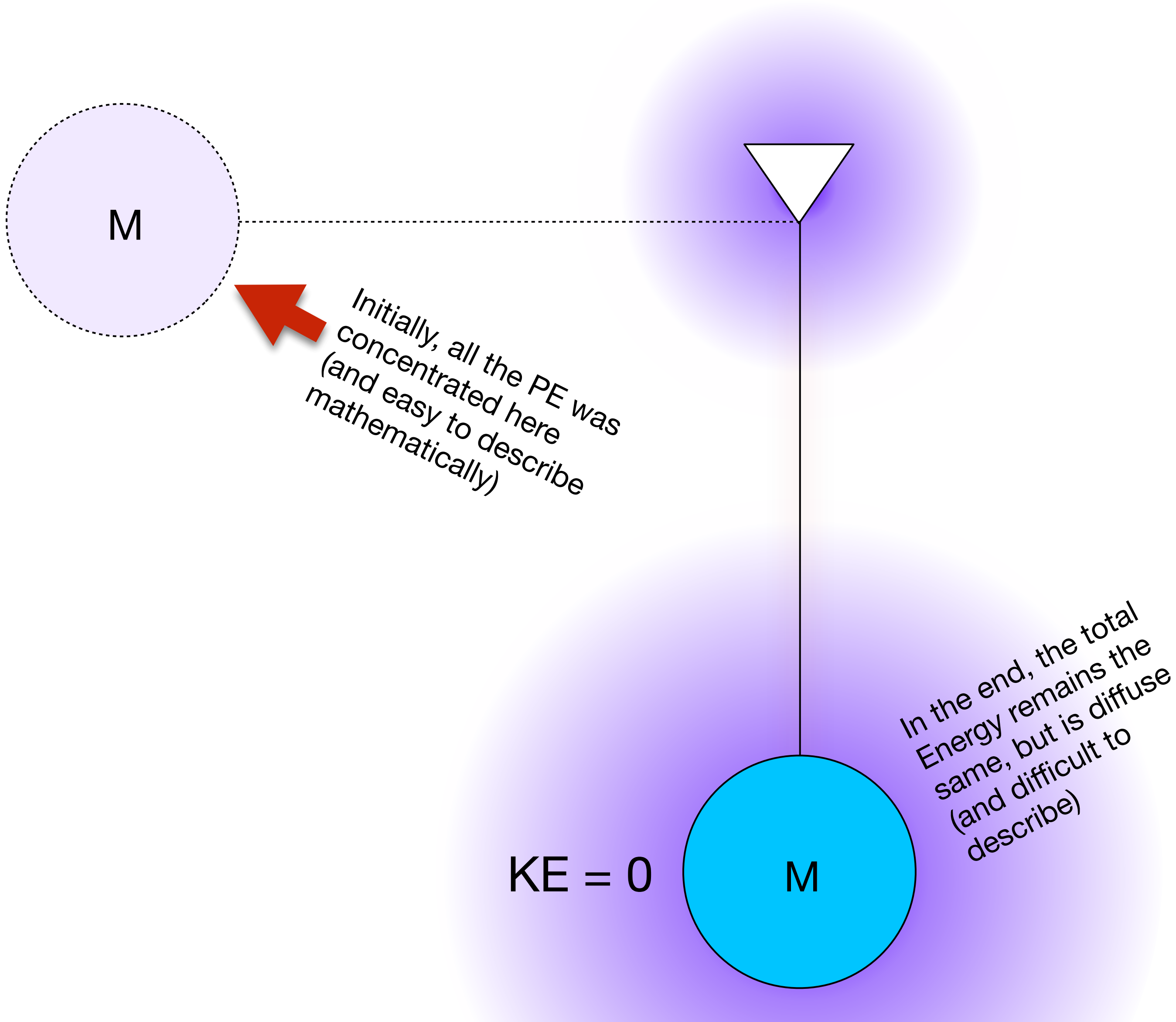
KE ~= PE (energy is conserved)

The 2nd law of thermodynamics:

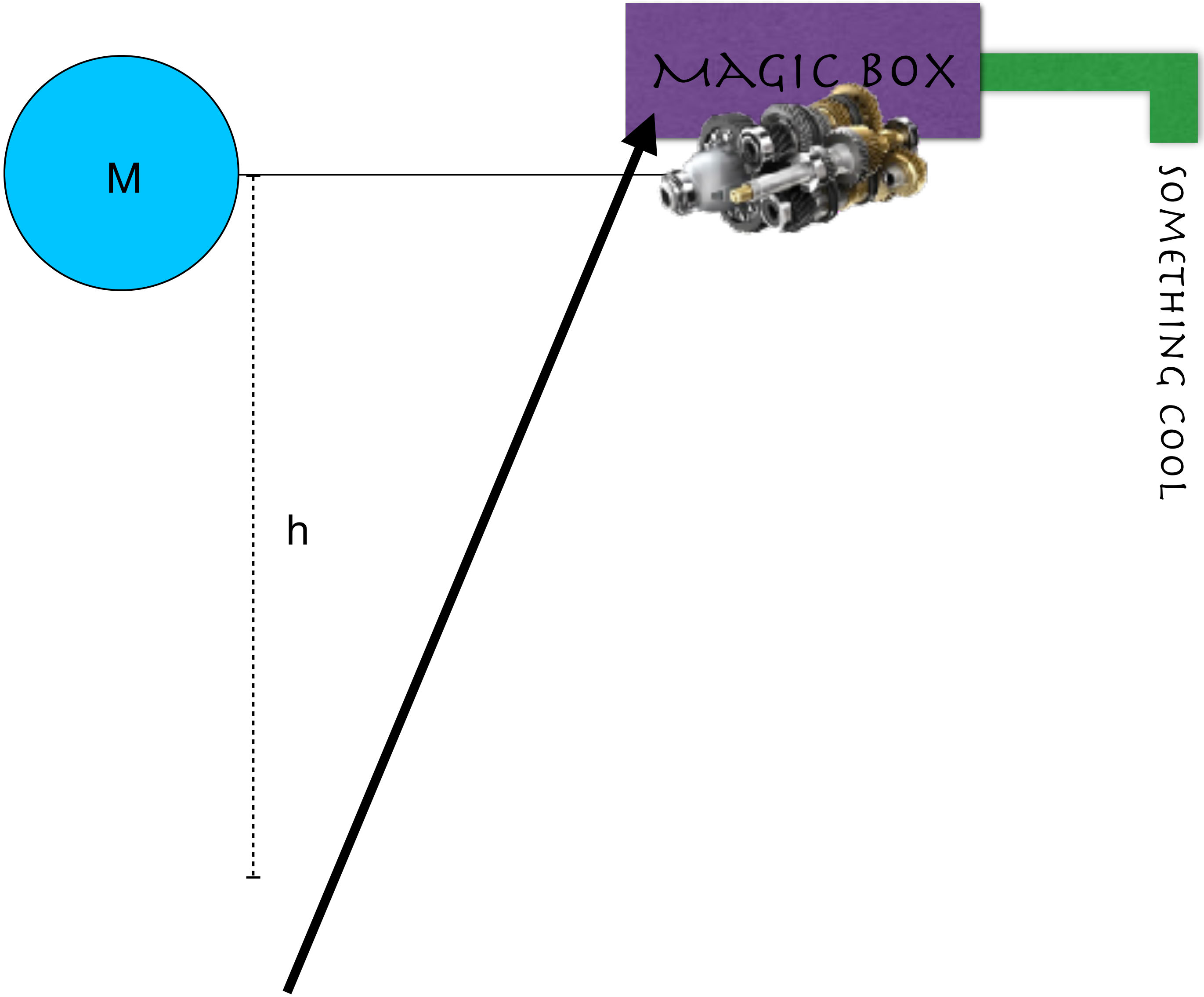
Not all of the energy in a system will be available to do the work we want.

aka 2nd law, "*Entropy increases over time*"

aka "You can't break even"



At end, we note 1st and 2nd laws. All of the original PE is *somewhere* (heat, noise, etc.), but is *more diffuse and less useful* to us.



This machine can't get do more work than initial energy input to the system (in this case, bound by PE = mgh).

Always remember:

Power (watts) = Energy (joules) / time (seconds)

Energy is a quantity. Power is a rate.

Technical take away:

We can make estimates of energy in systems (potential energy, kinetic energy) if we know mass, force, velocity, etc.

We can use these estimates to form maximum outside bounds as to the useful work we could get from a system.