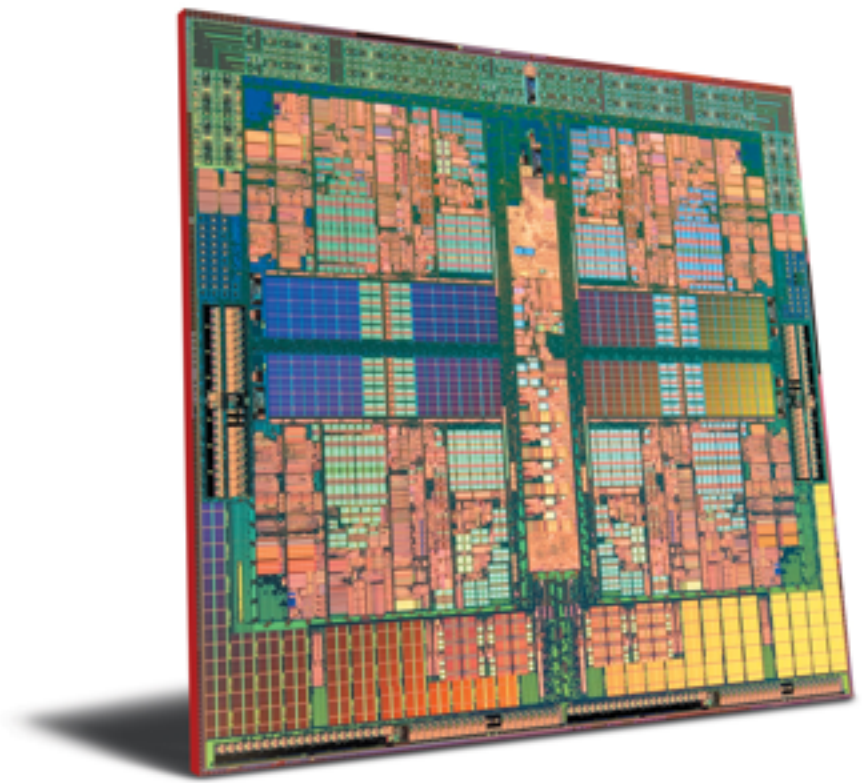
Kinetic Energy

Humans
move things

moving rocks



moving
electrons

To get things 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

Other units:

- "Lbs" or "pounds mass" is mass in English measure (also, "slugs"!)
- "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 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

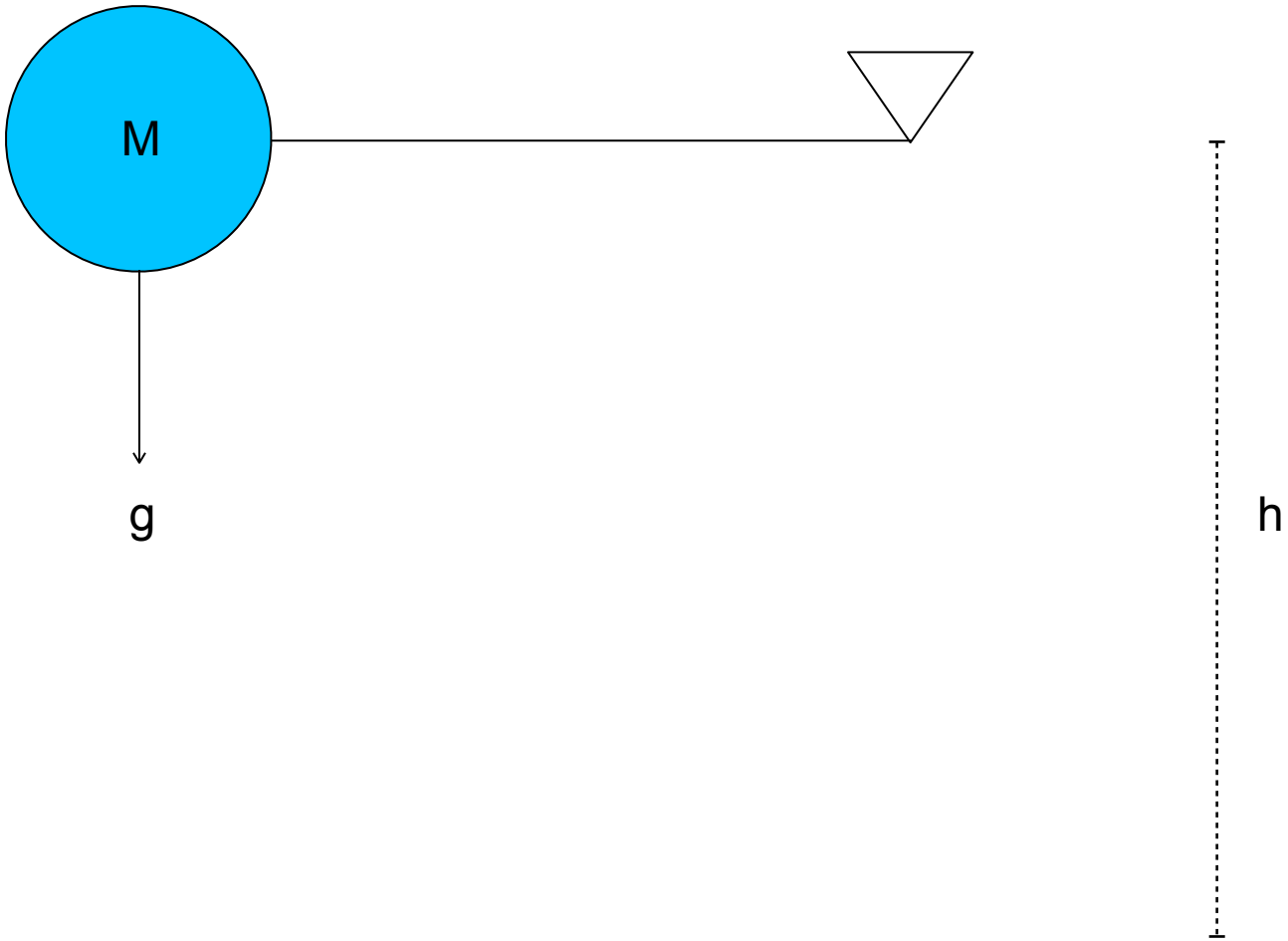
(1 joule) / (1 second) = 1 watt

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

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



$$PE = mgh$$

Kinetic energy is the energy of objects in motion:

Kinetic Energy = ½ mv2

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

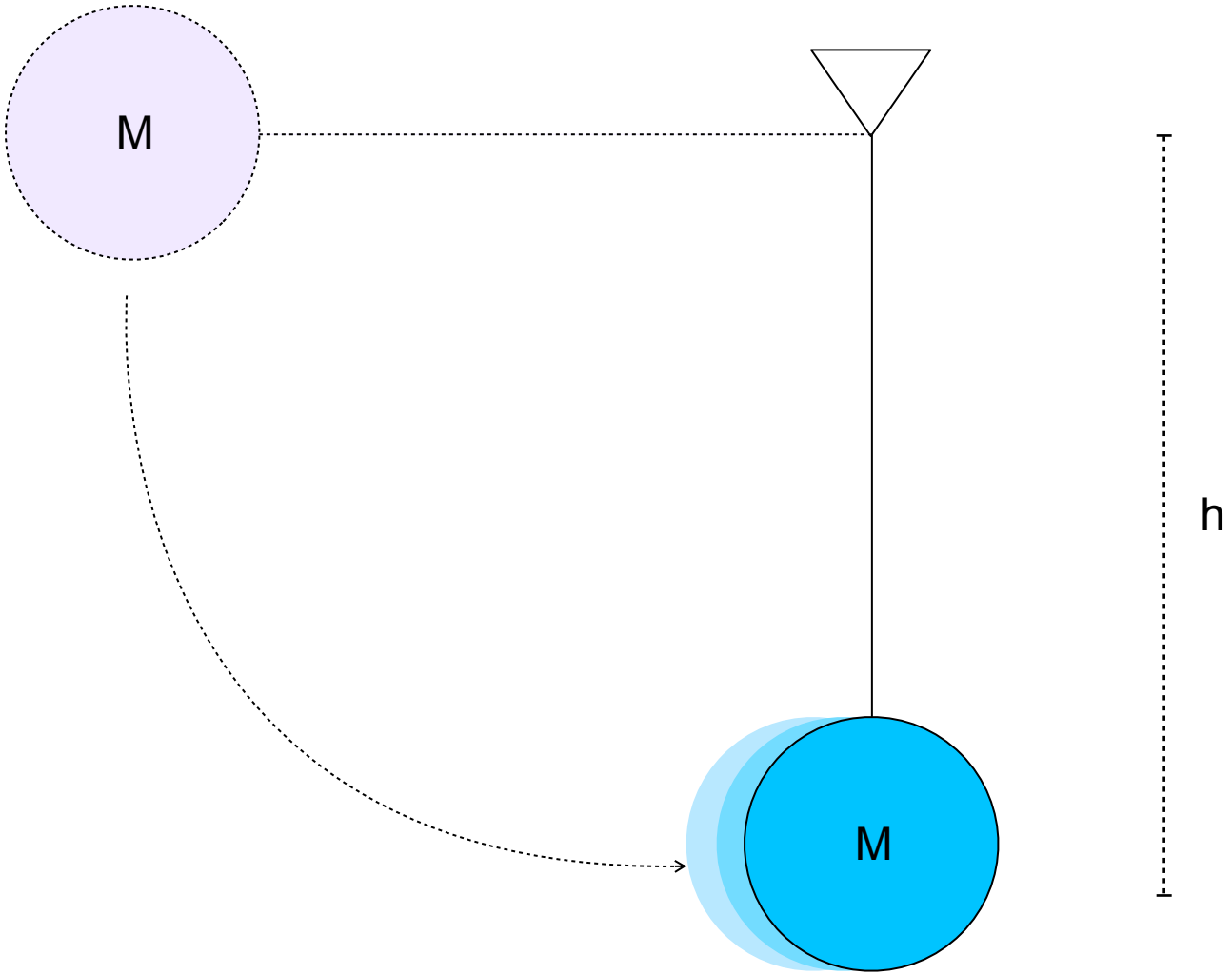
(1 / 2) * (1 kg) * ((1 (m / s))^2) = 0.5 joules

Rotational Work

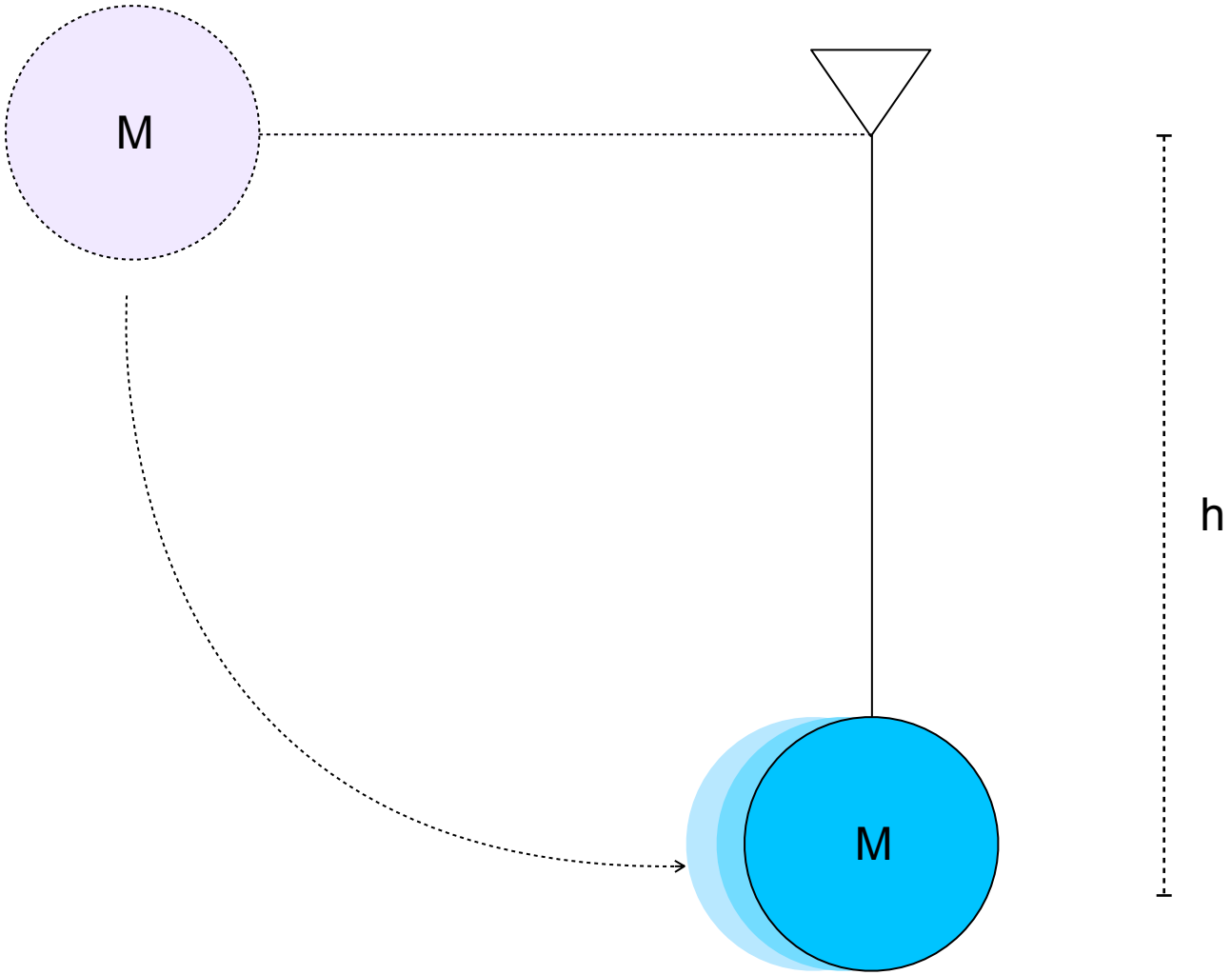
Same as linear work, but the force is traveling in a circle.

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

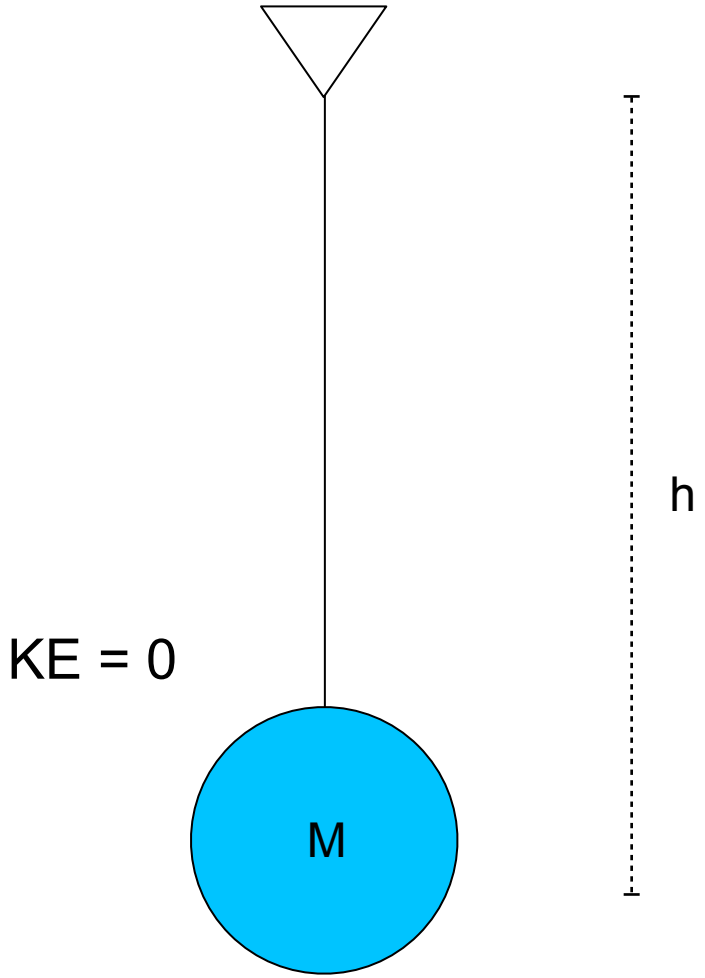
(1 newton) * 1 meter * (360 degrees) = 6.28318531 joules



$KE = \frac{1}{2} mv2$



On first swing, from 1st Law we know:
KE ~= PE (energy is conserved)



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.

Most important take away:

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

aka 1st law
aka "You can't win"

Not all of the energy in a system will be available to do the work we want.
aka 2nd law
aka "You can't break even"

Next most important take away:

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.