Flywheels

Learning Objectives

1) Indicate what is a flywheel
2) Describe how a flywheel operates
3) Mention the limits of fly wheel operation
4) Indicate material aspects associated with flywheels

Flywheel

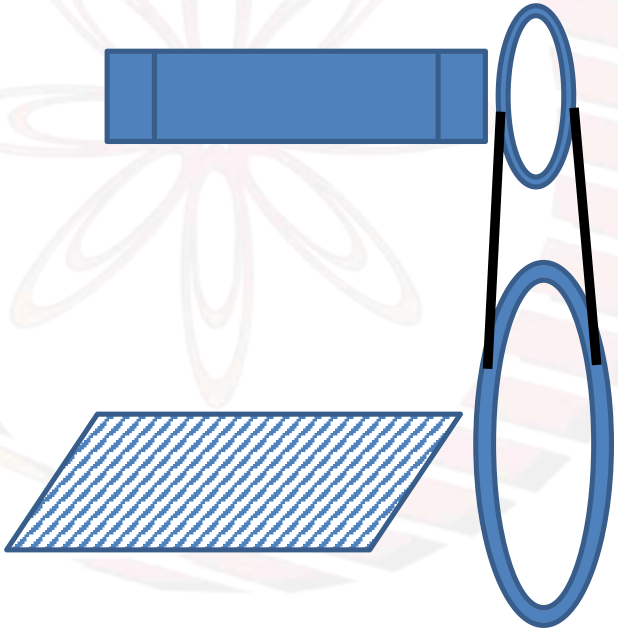
1) Mechanical energy storage device
2) Energy stored by increasing rpm of a rotating wheel
3) Energy extracted from the wheel, as needed which slows the wheel down

Flywheel

1) Smoothing of the power output of an energy source
2) Extends the ability of an energy source to operate outside of its rating by storing its energy and releasing it as needed
3) Regenerative braking

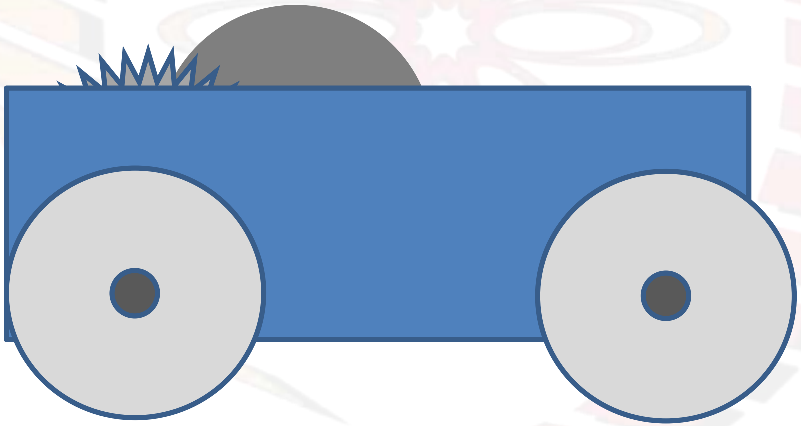
Examples

1) **Foot operated sewing machine**



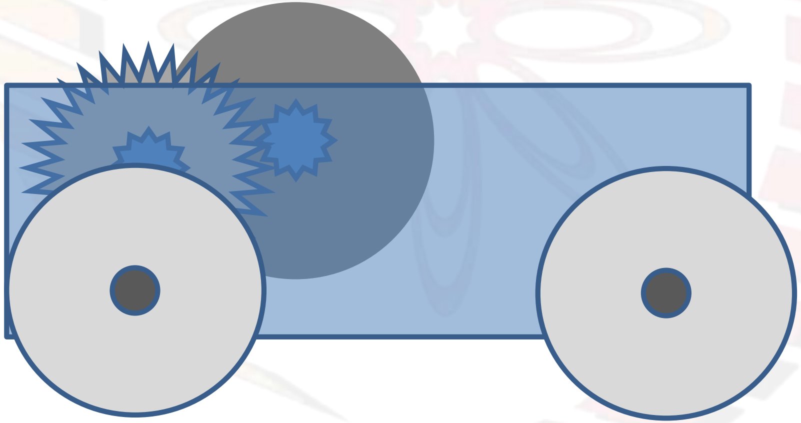
Examples

2) Toys



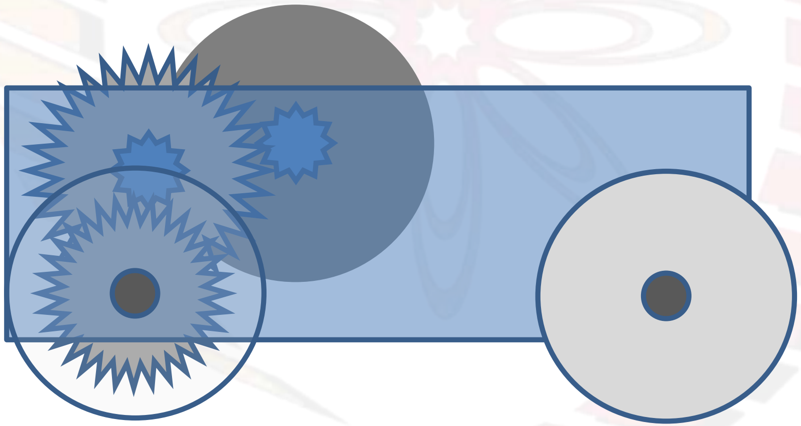
Examples

2) Toys



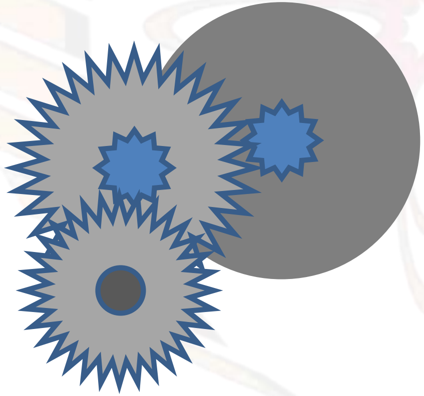
Examples

2) Toys



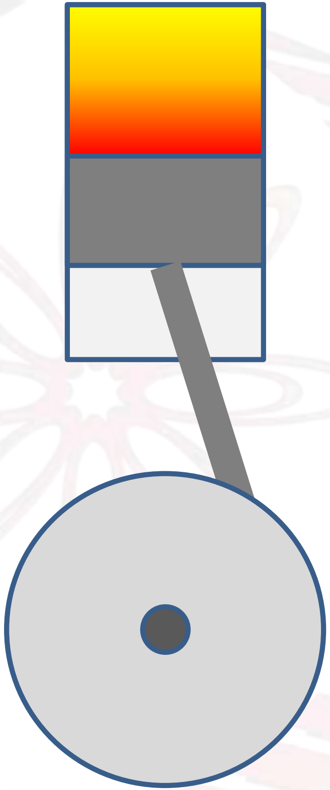
Examples

2) Toys



Examples

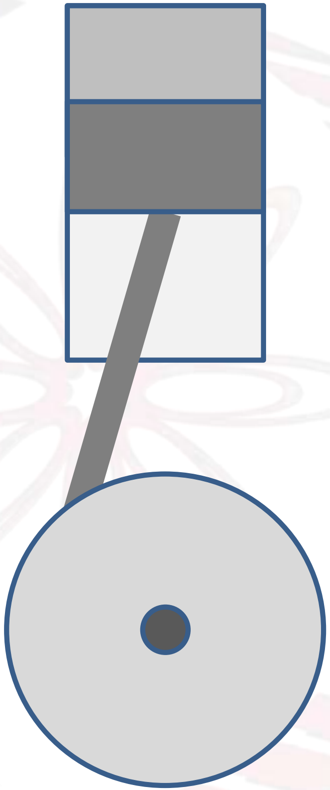
3) Reciprocating Engine



Energy stored during power stroke is used for the next intake stroke

Examples

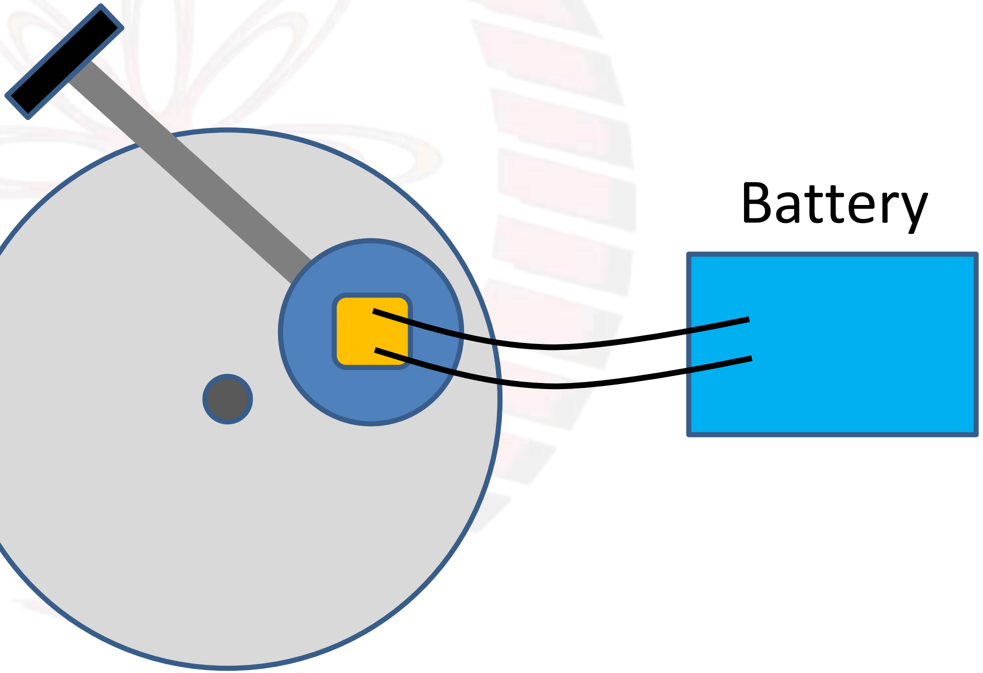
3) Reciprocating Engine



Energy stored during power stroke is used for the next intake stroke

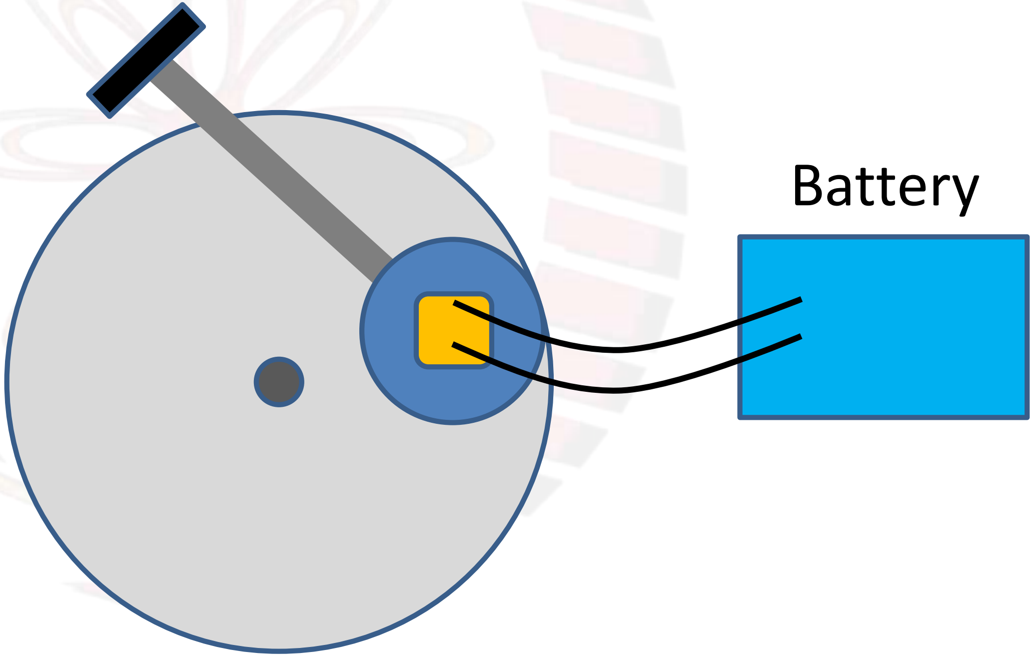
Examples

4) **Regenerative Braking**



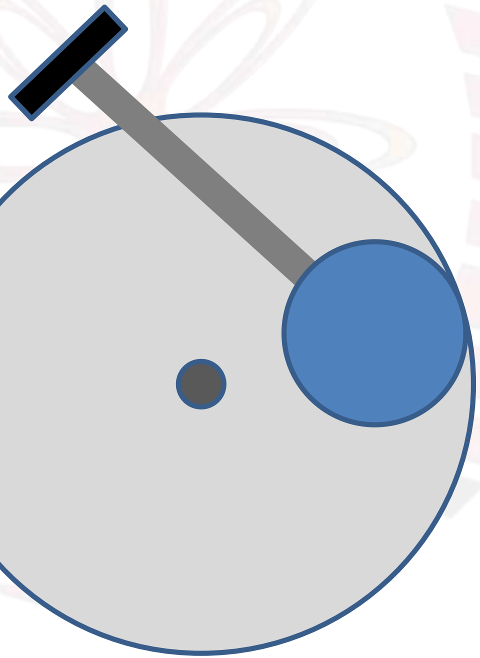
Examples

4) **Regenerative Braking**



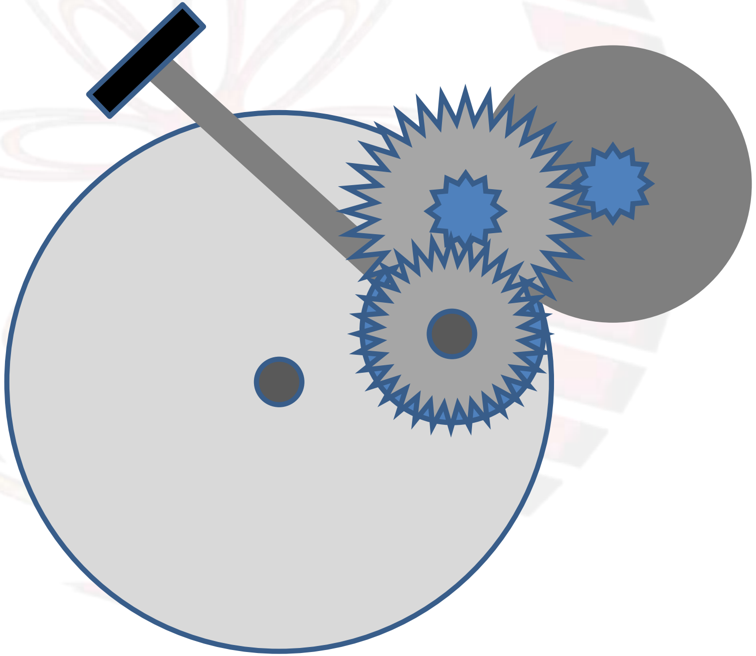
Examples

4) **Regenerative Braking**



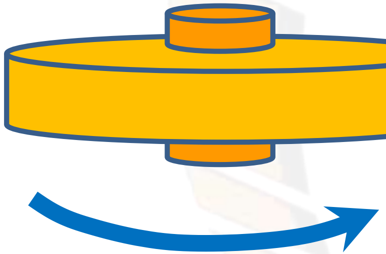
Examples

4) Regenerative Braking



$$E = \frac{1}{2} I\omega^2$$

Energy stored increases only linearly with mass, but with square of the angular velocity



Flywheels

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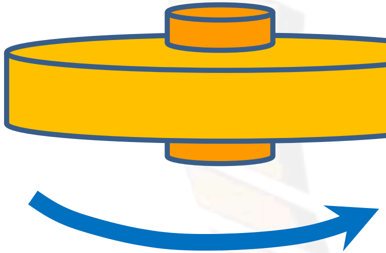
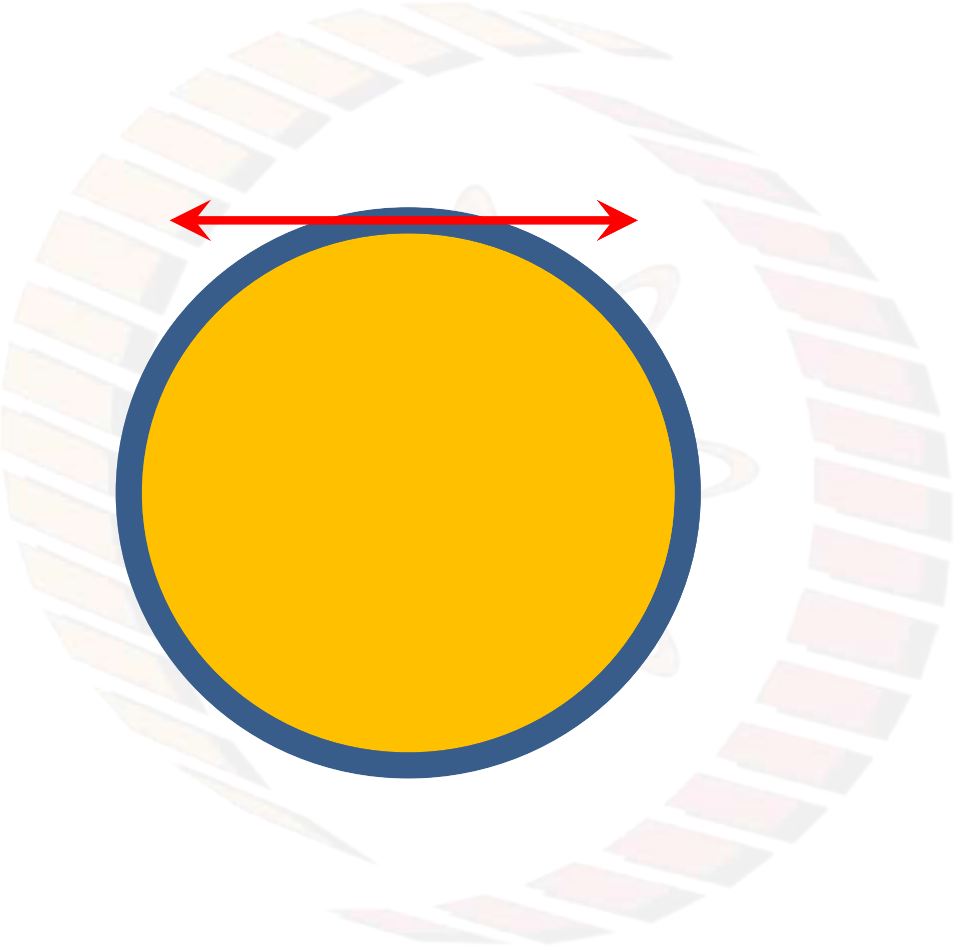
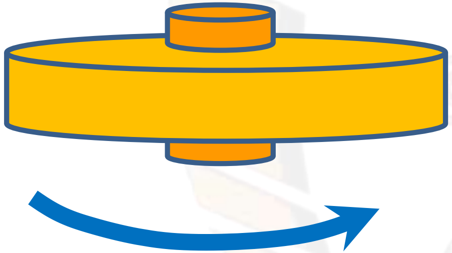


Flywheels

$$I = \frac{1}{2} mr^2$$

For a solid cylinder





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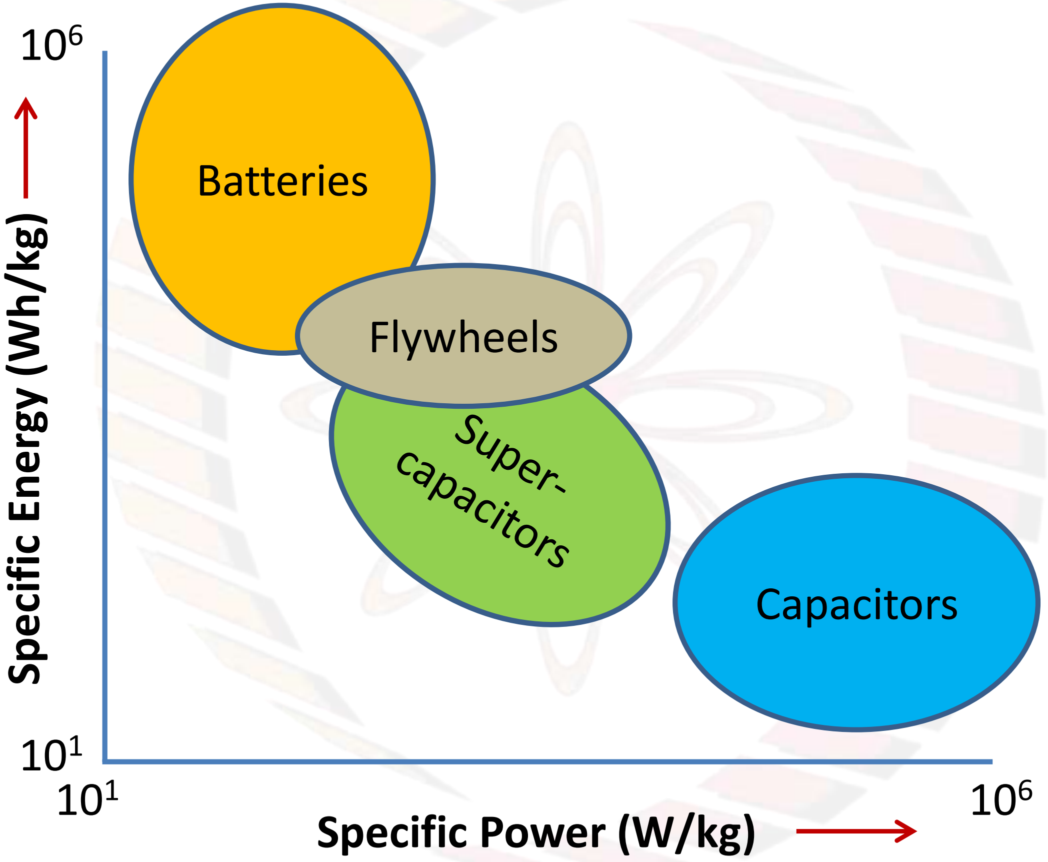
Tensile stress at rim of cylinder

When hoop stress in the rotor, exceeds the ultimate tensile of the rotor material, the rotor shatters



10^6
Specific Energy (Wh/kg)
Batteries
Flywheels
Super-capacitors
Capacitors
10^1
10^1
10^6
Specific Power (W/kg)

Material	kJ/kg
Lead Flywheel:	1
Cast Iron:	25
Carbon Fiber Reinforced Polymer:	150

CFRP: 60,000 rpm

Conclusions

1) Flywheels store energy using a rotating wheel
2) The energy stored increases as the square of the angular velocity and only linearly with the moment of inertia
3) The high angular velocities attained can result in the material disintegrating due to the forces involved
4) Mechanical properties of materials are therefore critical in enabling higher energy storage in flywheels