Unit 3: Work, Power, and Machines Guided Notes

Energy and its forms

Energy is the _____

Energy is needed to exert a _____ over a _____ in order to move an object.

Unit: _____ (J) -- Same as WORK!

WORK is the transfer of _____!

Objects can _____ because work is being done on them.

Types of Energy

- Kinetic Energy
- Potential Energy
  - _____
  - _____

Kinetic Energy (KE)

Energy an object has due to its _____

$KE = 1/2mv^2$

Unit: Joules (_____)

Dependent upon _____ and _____.

Potential Energy (PE)

Energy that is _____ as a result of _____ or _____.

Two types:

_____

_____

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Gravitational Potential Energy (PE_g)

Energy _____ in an object as the result of its vertical position or height (gravity)

The result of _____

Dependent upon _____ of object and _____ to which it is raised

_____ relationship between PE and mass

_____ relationship between PE and height of an object

Acceleration due to gravity is _____!

Gravitational potential energy = mass * gravity * height

PE_g = m * g * h

Elastic Potential Energy

Energy _____ in elastic materials as the result of their stretching or compressing

The _____ stretch or compression, the _____ potential energy!

**EXAMPLES: _____

Kinetic Energy (KE)

Moving energy

If an object is moving it has kinetic energy

$KE = 1/2mv^2$

****Why would tripling the speed at which a car is moving have a greater effect on its kinetic energy than tripling its mass?****

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Problems:

1. Calculate the kinetic energy of a 45 g golf ball travelling at: a) 20 m/s, b) 40 m/s c) 60 m/s

(hint: need to convert mass)

2. A 4 kg rock is rolling 10 m/s. Find its KE.

3. An 8 kg cat is running 4.0 m/s. What is its KE?

PE_g Practice

1. In 1993, Cuban athlete Javier Sotomayor set the world record for the high jump. The gravitational potential energy associated with Sotomayor's jump was 1970 J. Sotomayor's mass was 82.0 kg. How **high** did Sotomayor jump?

2. An 1750 kg weather satellite moves in a circular orbit with a gravitational potential energy of 1.69×10^{10} J. At its location, free-fall acceleration is only 6.44 m/s2. How **high** above Earth's surface is the satellite?

3. 3. With an elevation of 5334 m above sea level, the village of Aucanquilca, Chile is the highest inhabited town in the world. What would be the ***gravitational potential energy*** associated with a 64 kg person in Aucanquilca?

4. The Royal Gorge Bridge is situated 321 m above the Arkansas River in Colorado. If the gravitational potential energy associated with a tourist on the bridge is 1.73×10^5 J with respect to the river, what is the tourist's ***mass***?

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Forms of Energy

Mechanical:

Thermal:

Chemical:

Electrical:

Electromagnetic (Radiant & Solar):

Nuclear:

Cellular:

Energy Conversions

Law of Conservation of Energy

_____

_____

*******It changes into other forms...***

ENERGY CONVERSION

Mechanical -- Thermal -- Chemical -- Electrical -- Electromagnetic -- Nuclear

Energy Conversion Calculations

Mechanical Energy = _____ + _____

$(KE + PE)_{beginning} = (KE + PE)_{end}$

Energy and Mass

$E = mc^2$

E = _____
m = _____
c = _____ (speed of light, 3.0×10^8 m/s or 186,000 miles per second)

Energy and mass can be converted into each other

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Work

_____ is done when a _____ acts on an object in the same _____ the object moves.

_____ requires _____!

No movement = no work

Any part of the force that does not act in the direction of the motion does **no work on the object.**

Work Formula

Work = Force x Distance

Unit

N * m = Joule (J)

When a force of 1 Newton moves an object 1 meter in the direction of force, 1 Joule of work is done.

DRAW WORK FORMULA TRIANGLE HERE:

1. How much force would have to be applied to produce 40 J of work over a distance of 10 meters?

2. What distance would an object be moved if 50 N of force was exerted on an object and 100 J of work was completed?

3. How much work was produced when an object was moved 300 meters with a force of 10 N exerted on it?

Power

_____

More power = faster work

Less power = slower work

Power Formula

Power = work / time

or

Power = Force * distance / time

Unit

Watt = 1 Joule / second

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DRAW POWER FORMULA HERE:

1. A woman lifts a 300 newton child a distance of 1.5 meters in 0.75 seconds. What is her power output in lifting the child?

2. How much power does it take to lift 30.0 N 10.0 m high in 5.00 s?

3. You do 45 J of work in 3.0 seconds. How much power do you use?

1 HORSEPOWER = _____ watts

Work and Power Practice

1. Eva applies 40 N force to move her bookcase 3 m. How much work did Eva do?

2. Sheila did 110 J of work to move a chair 2 m to the right. How much force did Sheila use to move the chair?

3. How much power does it take to do 500 J of work in 10 s?

4. How much power does it take to lift 250 N, 40 m high in 2 seconds?

5. If it takes 20 N to move a box, how much power will be needed to move the box a distance of 5 meters in 5 seconds?

6. How much power does it take to lift 50 N 10 meters high in 10 seconds?

7. How long will it take a 100 W motor to lift a 5 kg mass 20 m?

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Work and Machines

Machine:

- _____
- _____
- Makes work easier to do

Like a car jack--

Little force applied on one end--

Big force on opposite side--

How do machines work?

1) _____

That car jack:

Small force exerted over a LONG distance (turning the crank) equals a large force over a SHORT distance (raising the car)

2) _____

Oars on a boat....

Decreases applied force, but applies the force to a greater area.

3) _____

Hey, the oar is a good example for this too!

Work input and output

What is friction?

_____

How does this relate to machines?
Because of friction, the work done by a machine is always less than the work done on the machine.

What is the definition of work?

_____

No machine is _____ efficient...

There is always a tradeoff.

Less force --> _____

More force --> _____

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Work input

Input force

_____
_____

Input distance

The distance the input force acts through

Work input = input **force** x input **distance**

$$W_i = f_i \times d_i$$

Work output

Output force

_____
_____

Output distance

The distance the output force is exerted through

Work output = output **force** x output **distance**

$$W_o = f_o \times d_o$$

Work Input and Work Output Practice

1. In order to raise a 250 N bale of hay to the loft 3.0 m high you use a pulley that requires you to apply only 100 N of force but you have to pull 15 m of rope. Calculate the work input and work output.

2. You attempt to use a pry bar to pull out a 7.5 cm nail from a block of wood. You apply 30 N of force and you push the pry bar 30 cm. Calculate the work input.

3. You raise an 1800 N fridge 1.5 m high onto a truck bed. To do this you push it up a 10 m ramp and apply 500 N of force. Calculate the work input and work output.

Mechanical Advantage and Efficiency

Mechanical Advantage

The number of times that the machine _____ an input force

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Actual Mechanical Advantage

Actual Mechanical Advantage (AMA) = Output force

Input force

Equals the _____of the output force to the input force...

Includes _____!!! Real world stuff!

Ideal Mechanical Advantage

Ideal mechanical advantage (IMA) = Input distance

Output distance

Absence of friction--IDEAL!

Because friction is **always** present, the actual mechanical advantage of a machine is always _____ than the ideal mechanical advantage.

AMA versus IMA

1. What is the IMA of a 3.5 cm screw of which the threads measure 9.5 cm in length?

2. Calculate the AMA of a pulley attached to a 435-N load, but requiring only 75 N to operate.

3. What is the AMA of a lever created from a plank of wood and a paint can if a 1540-N boulder is lifted with only 225 N of force?

4. Calculate the IMA of a ramp that is 4.0 m long and 1.5 m high.

Efficiency

No machine is _____ efficient

Some of the work put into a machine is used to overcome _____---all the time---no exceptions--period.

No machine is 100% efficient because some of the work put into a machine is used to overcome friction.

A percentage

Efficiency = Work output x 100

Work input

Comparison of the work going into a machine and the work coming out of a machine.

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Efficiency Problems

1. To pull a nail out of a wood board a carpenter does 1000 J of work. The hammer he uses does 835 J of work. What is the efficiency of the hammer?

2. A ramp is used to load furniture onto a moving truck. The person does 1240 J of work pushing the furniture up the ramp, and the ramp does 822 J of work. Calculate the efficiency of the ramp.

3. A lever does 765 J of work and the person using the lever applies 890 J of work. What is the efficiency of the lever?

Six types of simple machines:

1. _____ 3. _____ 5. _____
2. _____ 4. _____ 6. _____

Lever

A rigid bar that is free to move around a fixed point.

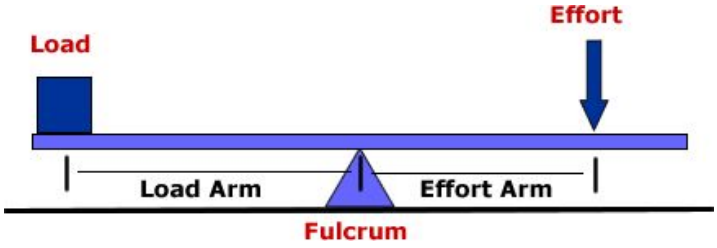
Fixed point = _____

Input arm = the distance between the input force and fulcrum

Output arm = the distance between the output force and the fulcrum

To calculate IMA of any lever, divide the input arm by the output arm.

Lever Parts



Three classes of levers (1st, 2nd, 3rd):

Position of _____ *identifies class*

First Class Levers

Fulcrum located _____ the input force and output force

IMA: >1, = 1, or <1

Examples: Scissors, seesaw

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Second Class Levers

_____ located between the input force and fulcrum

IMA: >1

Examples: wheelbarrow, nutcracker , car door

Third Class Levers

_____ located between the fulcrum and output force

IMA: <1

Example: Baseball bat, golf clubs

Wheel and Axle

Two _____ or cylinders, each one with a different radius

Outer disk = _____

Inner cylinder = _____

To calculate the IMA, divide the radius where the input force is exerted by the radius where the output force is exerted

IMA = >1 or <1

Inclined Plane

_____ surface along which forces moves an object to different elevation.

The IMA is the distance along the inclined plane divided by its change in _____.

Examples: _____!

Wedge

V-shaped object whose sides are two _____ sloped toward each other.

A thin wedge of a given length has a greater IMA than a thick wedge of the same length.

Examples: _____

Screw

An _____ wrapped around a cylinder

Screws with threads that are _____ together have a greater IMA.

Examples: _____

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Pulley

A simple machine that consists of a _____ that fits into a groove in a wheel.

Output force is different in size, direction, or both from that of the input force.

IMA is equal to the number of rope sections supporting the load being lifted.

Three types: _____

Fixed Pulley

_____ is attached in a fixed location

Direction of exerted force is changed by a fixed pulley--not force

IMA = 1

If friction is _____, input force and output force should be about equal.

Examples: _____

Moveable Pulley

A pulley attached to the object being moved rather than to a fixed location.

Change both _____ and _____ of input force

Examples: _____

Compound Machines

A _____ of two or more simple machines that operate together.

The output force of one simple machine is the input force of another.

Examples: _____

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Mechanical Waves

Mechanical Waves

_____

_____

Medium

Material through which the wave travels

**Can be solid, liquid, or gas!

*Mechanical waves are created when a source of **energy** causes a **vibration** to travel through a **medium***

Vibration: back and forth motion!

Examples…

Types of Mechanical Waves

- ***Transverse*** waves
- ***Longitudinal or compressional*** waves
- ***Surface*** waves

Transverse Waves

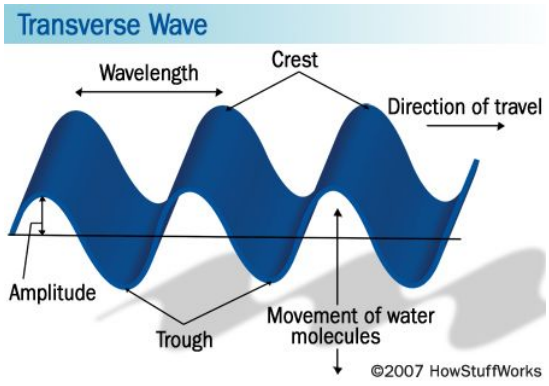
- The motion of the medium is at _____ to the direction of the wave...
- What is a right angle? _____
- Examples: _____

Crest

Highest point above rest position

Trough

Lowest point below rest



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Longitudinal or Compressional Waves

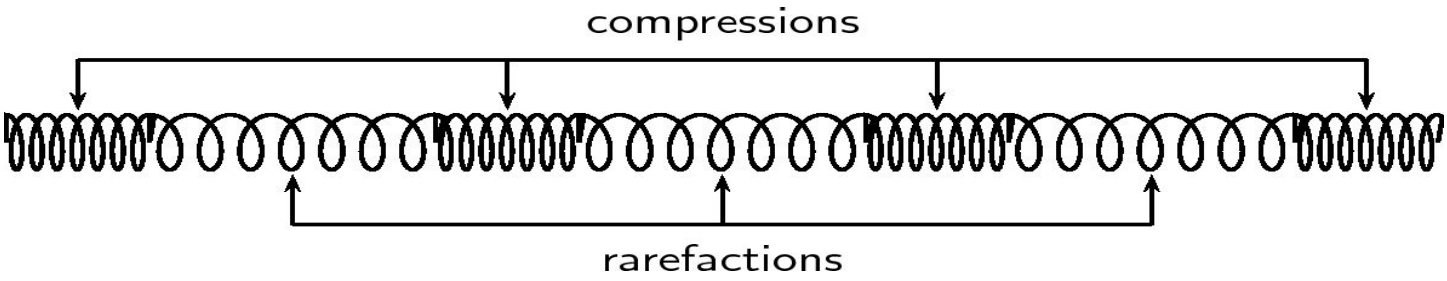
Movement of the _____ is in the _____ as, or the _____ to, the _____ of the wave

Compression

_____
_____

Rarefraction

_____
_____



Also called _____

Examples:

_____

Surface Waves

- Wave that travels along a surface _____ two _____
- Most surface waves do not transport matter from one place to another

Across the surface of the object, not through it

Examples:

_____
_____

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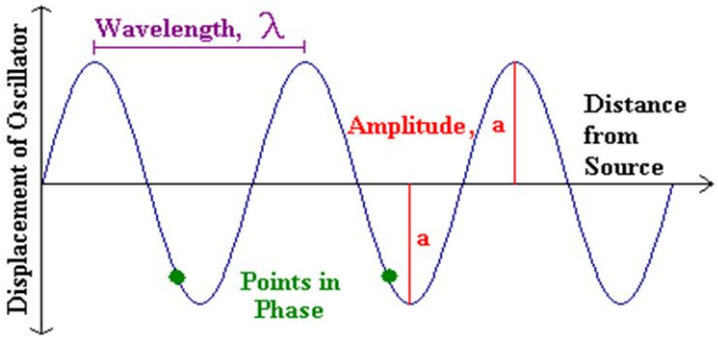
Properties of Mechanical Waves



Frequency and Period

Periodic motion

- _____

Period

- _____

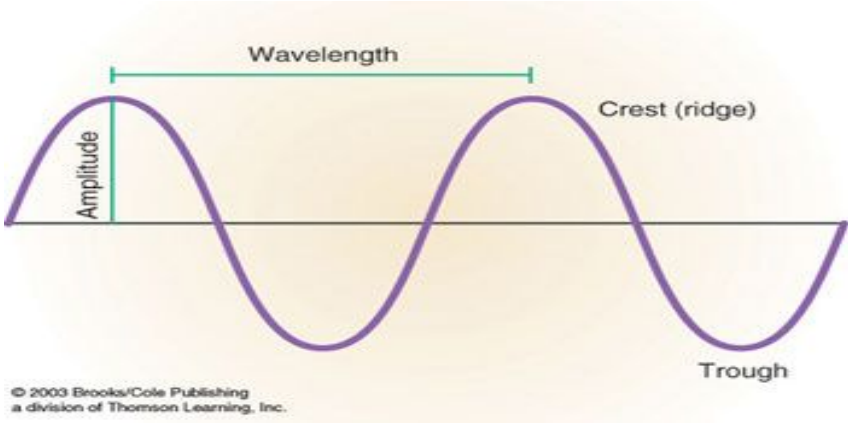
Frequency

- number of _____
- measured in hertz (Hz)

A wave's frequency equals the frequency of the vibrating source producing the wave

Wavelength

- The distance between a point on one wave and the same point on the next cycle of the wave
- ***Unit:*** _____
- ***Symbol:*** _____
- ***Increasing the*** _____ ***of the wave decreases its*** _____



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Wave Speed

- ***Speed*** = _____ x _____
- **Units**: _____ (m/s)

Amplitude

- _____ displacement of the medium from its rest position...
- **MORE** _____ --> **GREATER** _____

Sound Waves

Sound waves are _____ waves

Properties of Sound Waves

- _____
- _____
- _____

Speed of sound

- 342 meters per second or 761 miles per hour
- Travels _____ in solids, _____ in liquids, and _____ in gases
- Depends on _____ and elasticity of medium

Intensity and Loudness

Intensity

- the rate at which a wave's energy flows through a given area
- Depends on wave's _____ AND _____ from the sound source
- Whisper in the ear versus across the room
- Measured in _____ (dB)

Loudness

- Physical response to the _____ of sound

Frequency and Pitch

Pitch

- _____
  _____
- Depends of wave's _____!
  - **High** _____ = **high** _____
  - **Low** frequency = **low** pitch
- High pitch sounds usually impaired first--

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Ultrasound

Human hearing between 20 Hz and 20,000 Hz

Infrasound--_____

Ultrasound--_____

- SONAR and ultrasound imaging

SONAR

- **SO**und **N**avigation **A**nd **R**anging
- Uses sound propagation for _____
    - Used widely during WWI and WWII
- _____
- Some animals are evolved with this ability!

The Electromagnetic Spectrum

Electromagnetic waves (EM)

- _____ waves consisting of changing electric fields and changing magnetic fields
- Do not need a _____
- _____ require a medium---**CANNOT** travel through the vacuum of space
- _____ do not require a medium---**CAN** travel through the vacuum of space
- EM waves have different frequency and wavelengths but they all travel at the _____.
- Velocity: ***3.0 x 10^8 m/s*** or 186,000 miles per second

The Electromagnetic Spectrum
Energy increases with increased frequency.

Remember: Visible light is just one small part of the EM spectrum. Visible light is the part that our eyes can detect.