



Grade 6 Math Circles

February 11/12 2020

Applications

Energy

What is energy?

Energy is the ability to do _____. It is a property that allows things to _____.
It takes energy for us to...



- Lift our arms.
- Jump up and down.
- Walk to school.

...and so much more.

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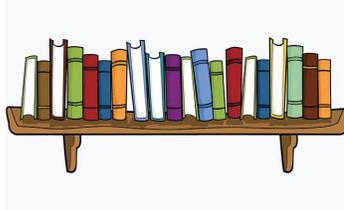
Some types of energy:

- **Kinetic energy:** The energy an object possesses from being in _____, because something had to transfer energy to it in order for it to move.



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- **Gravitational potential energy:** Energy that is _____ due to an object being _____. When objects aren't moving, they can have the potential to move due to the energy stored in them. For example, a book on a shelf is not moving, but it has gravitational potential energy because if someone were to nudge it, it would fall to the ground due to gravity (therefore it would move).



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- Light energy.
- Heat energy.

Exercises:

1. Write down 2 examples of things that have kinetic energy.

2. Write down 2 examples of things that have gravitational potential energy.

A Closer Look at Kinetic Energy

Harry Potter, 60 kg, is running away from a group snatchers in the woods at a speed of 10 m/s. When he is caught, the snatchers tell him that if he can calculate how much kinetic energy he had while running, they won't capture and bring him to Voldemort. How can Harry do this?

Calculating kinetic energy:

$$KE = \frac{1}{2} \times m \times v^2$$

Where...

KE stands for kinetic energy, measured in joules (J).

m is the mass in kg.

v is the speed in m/s.

So, Harry must use...

To calculate...

Exercise:

You pitch a baseball to a batter. Using a radar gun, you find that the speed at which you pitched the baseball was 27 m/s. If the baseball has a mass of 149 g, what is the kinetic energy of the baseball after you let go of the ball?

A Closer Look at Gravitational Potential Energy

Harry Potter is in the middle of trying to retrieve an egg from a dragon for his first task in the triwizard tournament. Unfortunately, while flying on his broom he falls and finds himself hanging off the ledge of a building, 45 m above the ground. He eventually recovers and is able to retrieve the egg, but loses points for poor technique because he fell off of his broom during the task. The judges tell him that he may earn back the points he lost if he can calculate what his gravitational potential energy was while he was hanging from the building. How can Harry do this?

Calculating gravitational potential energy:

$$PE = m \times g \times h$$

Where...

PE is the gravitational potential energy, measured in joules (J).

m is the mass in kg.

g is the gravitational constant (9.8 m/s^2).

h is the height of the object above the ground in meters (m).

So, Harry must use...

To calculate...

Exercise:

You race to get on the Leviathan first thing in the morning at Canada's Wonderland. The total mass of the car and everyone on the ride when you go on is 3360 kg. When you get to the top and stop, the car is 93 m above the ground. How much potential energy does the car have?



Retrieved from www.themeparktourist.com

The Wave



Retrieved from
www.sciencefocus.com

Retrieved from
www.disneyclips.com

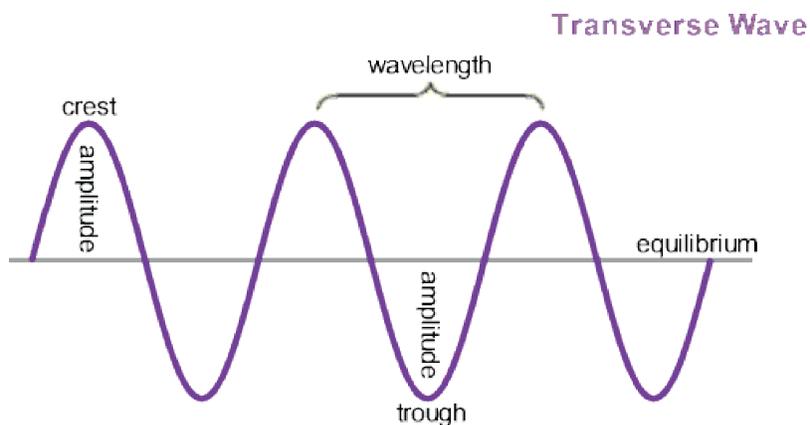
Retrieved from
www.theguardian.com

What is a wave?

Waves are a method of _____. A wave is something that travels through space and transfers energy from one place to another.

For example, _____ is a wave. Light travels through the air as a wave and transfers light energy to objects. Think of how plants get energy from the sun during photosynthesis. This is due to the waves of light transferring energy from the sun to the plants, so that they are able to create sugar.

What does a wave look like?



Retrieved from <https://www.toppr.com/guides/physics/waves/transverse-wave-and-longitudinal-wave/>

Crest: All the _____ (or maxima) of the wave.

Trough: All the _____ (or minima) of the wave.

Wavelength (λ): The _____ between two consecutive _____ or two consecutive _____.

Equilibrium: The _____ between the crests and the troughs.

Amplitude: The _____ from the equilibrium line to a _____.

Frequency and Wavespeed

Frequency (f): The number of times one full wavelength passes a fixed point in _____ (measured in cycles/s, otherwise known as Hertz (Hz)). Frequency

$$f = \frac{\# \text{ of cycles}}{\text{Time in seconds}}$$

Wavespeed (v): How _____ the wave is travelling in m/s (the same way you would measure the speed of a car).

The Wave Equation

$$v = f \times \lambda$$

Where we measure v in m/s, f in Hz and λ in m.

This equation tells us that if we know the frequency and wavelength of the wave, we can find its wavespeed.

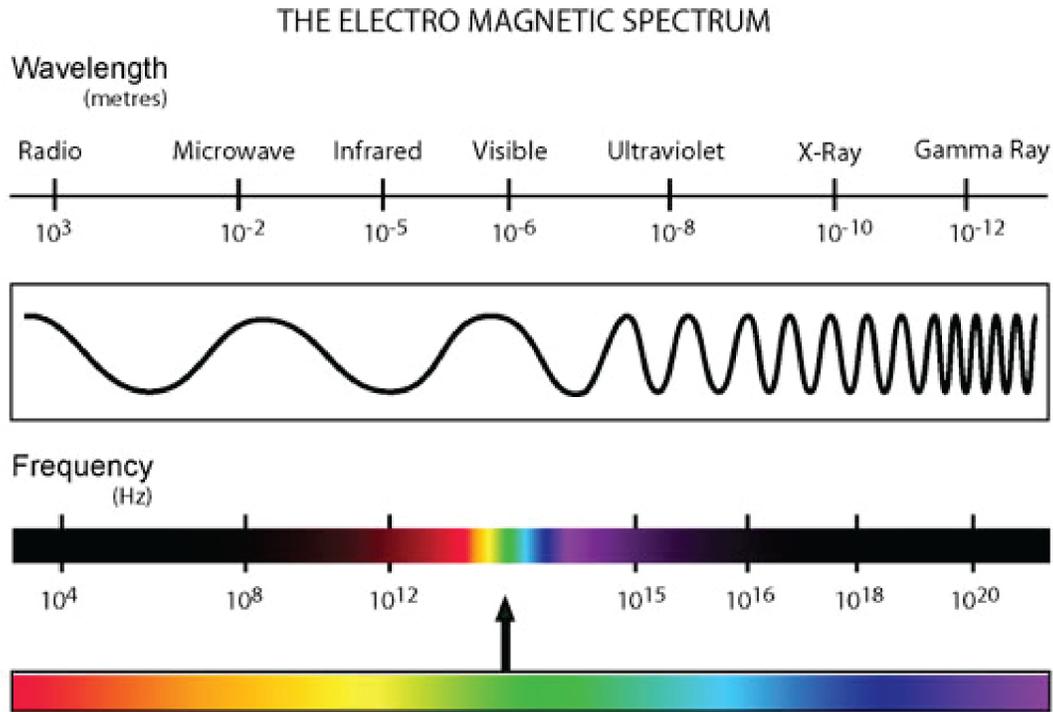
Example:

Your teammate is up to bat and hits a homerun! The sound wave from the bat hitting the ball has a frequency of 2000 Hz and a wavelength of 17 cm. How fast is this wave travelling?

Exercise:

1. The wavelength of a beam of red light is 0.00000068 m. The frequency of this beam of light is 441,000,000,000,000, Hz. What is the speed of this light wave?

The Electromagnetic Spectrum



Retrieved from: <https://mydarksky.org/2008/10/29/what-is-a-gamma-ray-burst-its-history/>

Here we see waves that have a _____ wavelength on the left, and a much _____ wavelength on the right. These are all _____, but the type of light wave depends on the _____.

The _____ section on the spectrum shows us the wavelengths of light that we are able to see, which is why we refer to it as visible light.

All of the other types of light here, we _____ with our eyes. However, there are some devices that can be used to detect other types of light.

Exercises:

Order the visible wave colours from largest to smallest wavelength. Hint: It is the same as the order of colours in the rainbow.

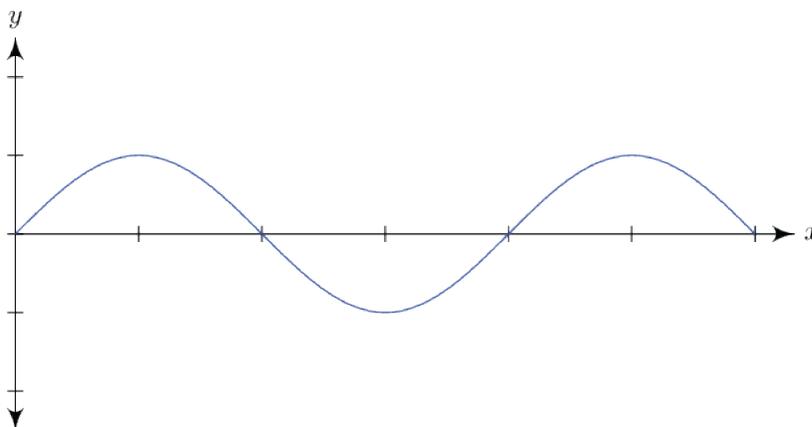
Which has the smallest wavelength: microwaves, visible waves or X-rays?

Problem Set

* Indicates challenge questions.

1. List the types of energy (kinetic or gravitational potential energy) that the following items possess:
 - (a) A car driving along the road.
 - (b) A ball sitting still on the top of a hill.
 - (c) A ball soaring through the air.
 - (d) A phone I hold still in my hand at eye level.
 - (e) A skier skiing down the middle of a hill.
 - (f) A bowling ball rolling along the alley.
2.
 - (a) A sprinter is running along the track at 4 m/s. If the mass of this sprinter is 70 kg, what is their kinetic energy?
 - (b) * If another sprinter has a kinetic energy of 398 J and a mass of 65,000 g, how fast are they running?
3.
 - (a) Mickey is standing at the top of a ladder that is 7.5 m from the ground. If Mickey has a mass of 50 kg, what is Mickey's gravitational potential energy at the top of the ladder?
 - (b) Mickey throws Minnie a birthday party in which he orders 50 tons of cheesecake. As a result of this, Mickey eats a lot of leftover cheesecake everyday for multiple weeks. He gains 10 kg.
 - i. How much does Mickey weigh now?
 - ii. Mickey is at the top of the same ladder again. What is his new gravitational potential energy?
 - (c) *Mickey signs up for a gym membership once all the cheesecake is gone. As a result, he has lost weight and is in great shape! When Mickey is at the top of his ladder again, his gravitational potential energy is 3.307 KJ. How much weight did Mickey lose since going to the gym?
4. Which of the following has more gravitational potential energy: A 0.5 kg ball sitting on top of a shelf that is 1 m above the ground, or a 0.5 kg ball sitting on top of a shelf that is 2 m above the ground?

5. What happens to the gravitational potential energy when the height is doubled? (Hint: Use the equation $PE = m \times g \times h$).
- (A) It is doubled. (B) It is tripled. (C) It is halved. (D) Changing the height has no effect on the gravitational potential energy.
6. *What happens to the kinetic energy when the speed is halved?
- (A) It is halved. (B) It is doubled. (C) It decreases by a factor of $\frac{1}{4}$. (D) It decreases by a factor of $\sqrt{\frac{1}{2}}$.
7. How many crests can be seen in the following wave? How many troughs?



Retrieved from <https://www.shmoop.com/waves/quiz-3-true-false.html>

8. If the amplitude of a wave is 2 cm, what is the vertical height between a trough and a crest of this wave?
9. (a) If one full wavelength of a wave passes a fixed point 5 times in one second, what is the frequency of this wave?
- (b) *If it takes one full wavelength of another wave 5 seconds to pass a fixed point 20 times, what is the frequency of this wave?
10. (a) A wave has a frequency of 10 Hz and a wavelength of 80 cm, what is the wavespeed of this wave?
- (b) *Another wave has a frequency of 103 Hz and a wavespeed of 60 m/s, what is the wavelength of this wave?

11. (a) A beam of yellow light on a traffic light tells cars when to slow down. Based on the electromagnetic spectrum, what type of light (or wave) is this?
- (b) According to the electromagnetic spectrum, which type of wave has the largest wavelength?
- (c) You detect a wave with a wavelength of 2.0×10^{-5} m. What type of wave do you conclude this is?