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Grade 7/8 Math Circles

March 3/4/5 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.

Retrieved from https://www.disneyclips.com/images/goofy5.html

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.

Retrieved from http://clipart-library.com/running-cartoons.html

- **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, meaured 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:

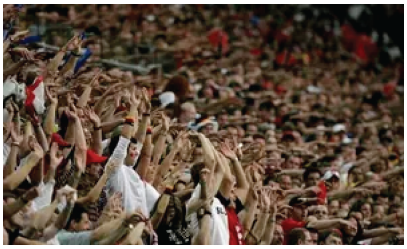
You race to get on the Leviathan first thing in the morning at Canada's Wonderland. The total mass of the car and everyone on the ride when you go on is 3360 kg. When you get to the top and stop, the car is 93 m above the ground. How much potential energy does the car have?

Retrieved from www.themeparktourist.com

The Wave

Retrieved from www.sciencefocus.com

Retrieved from www.disneyclips.com



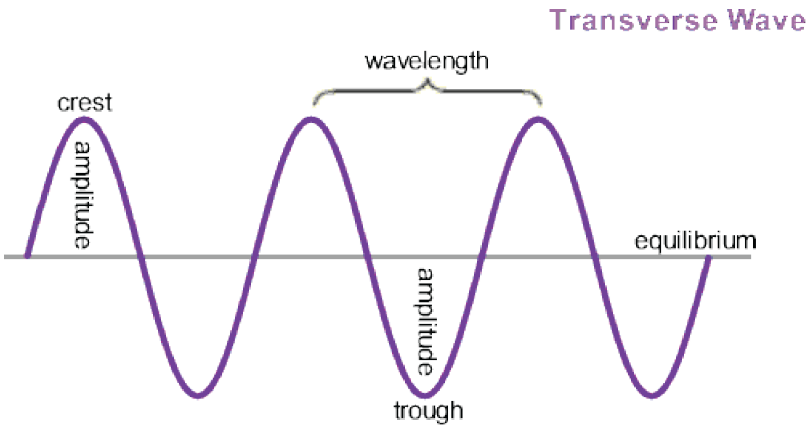
Retrieved from www.theguardian.com

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 tranfers 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 fro 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 _____ (meausured 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?

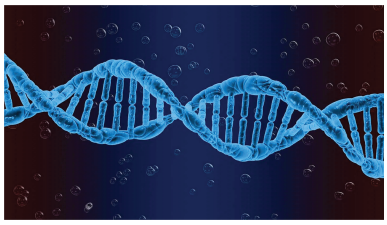
Exercise:

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?

Genetics

What is genetics?

Genetics is the study of _____ that living things _____. You have probably noticed that people tend to look similar to their parents. This is because they get, or "inherit" their parents' genes.



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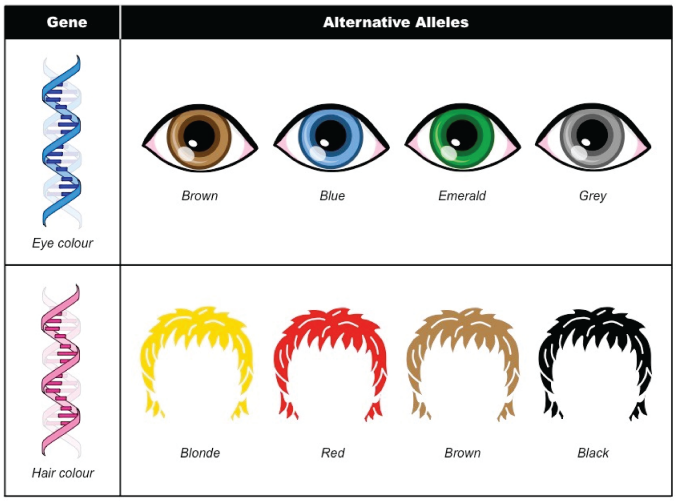
What are genes?

Genes are _____ that _____ for different _____ in your body. For example, you have genes that code for your eye colour, hair colour and whether you are right or left handed.

What about alleles?



As mentioned, we have genes that code for eye colour, but not everyone has the same colour of eyes. This means that there exists different _____ of each _____. We refer to the different types of genes as _____. The genes that code for our eye colour may have a _____ or a _____, giving different people different colours of eyes.

Retrieved from https://ib.bioninja.com.au/standard-level/topic-3-genetics/31-genes/alleles.html

How can we guess at what eye colour the baby of two parents will have?

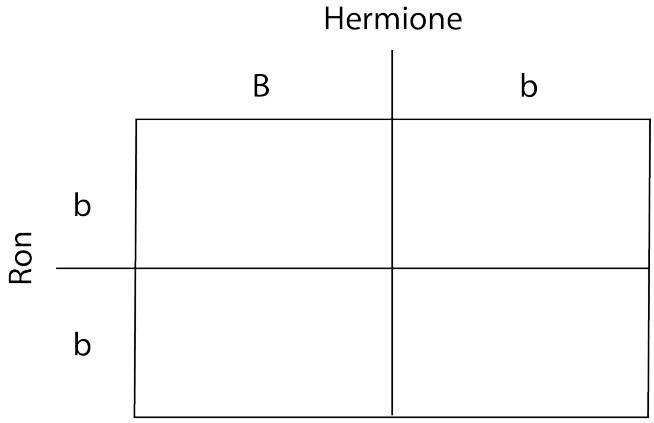
For eye colour, everyone inherits _____ allele from their _____ and _____ from their _____. They can either inherit a _____ allele or a _____ allele from each parent. So, if B = brown and b = blue, the possible combinations of alleles each person can have are...

- _____
- _____
- _____

So, we can guess that if you have the combination _____, you have _____ eyes, whereas if you have the combination _____, you will have _____ eyes. What if you have the combination Bb? Brown is known as the _____ allele, meaning that you only need _____ brown allele to have brown eyes. So, if you have the combination _____, you will have _____ eyes because the _____ allele overpowers the _____ one (_____).

Example:

Ron Weasley and Hermione Granger have a child named Rose. If Ron has blue eyes (bb) and Hermione has brown eyes (Bb) , without looking at Rose's eyes, what is the probability that she will have brown eyes?



To calculate the probability of having brown eyes, we can first write this as a fraction and then a percentage.

We know that there are four different possible combinations of alleles that Rose can have from our table, so our denominator will be _____.

How many of these combinations will cause Rose to have brown eyes? _____.

So the probability that Rose will have brown eyes, written in fraction form, is _____.

Written as a percentage, the probability that she will have brown eyes is _____.

Exercise:

Lupin and Tonks have a son named Teddy. If both Lupin and Tonks have brown eyes with alleles Bb, what can you guess that Teddy's eye colour will be?

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 kg, 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 3307 J. 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 $(\frac{1}{2})^2$. (D) It decreases by a factor of $\sqrt{\frac{1}{2}}$.

7. *The law of conservation of energy tells us that energy cannot be created or destroyed. This means that the total amount of energy of a system has to be the same all the time. While energy may transform between the different types of energy, the total amount of energy will not change.

   (a) I hold a ball in my hand, 2 m off the ground. At this moment, the ball has only gravitational potential energy. When I drop the ball, just before it hits the ground, it has only kinetic energy.

      i. If the gravitational potential energy when I'm holding the ball is 54 J, what will the kinetic energy of the ball be just before it hits the ground?

      ii. What is the speed of the ball just before it hits the ground? (Hint: Set the equations for KE and PE equal to each other).

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 0.8 m, 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) Neville Longbottom has brown eyes with allele combination BB. Luna Lovegood has blue eyes with allele combination bb. What are the chances that their child has blue eyes? (Express as a percentage).

    (b) *A child has blue eyes. His sister has brown eyes, with alleles BB. If both children have the same parents, find the allele combination for the eye colour of each parent.