National Certificate of Educational Achievement
TAUMATA MĀTAURANGA Ā-MOTU KUA TAEA

Exemplar for Internal Achievement Standard

Physics Level 2

This exemplar supports assessment against:

Achievement Standard 91169

Demonstrate understanding of physics relevant to a selected context

An annotated exemplar is an extract of student evidence, with a commentary, to explain key aspects of the standard. It assists teachers to make assessment judgements at the grade boundaries.

New Zealand Qualifications Authority

To support internal assessment

1	Low Excellence
	For Excellence, the student needs to demonstrate comprehensive understanding of physics relevant to a selected context. This involves linking ideas to integrate physics relevant to the selected context. It may involve elaborating, justifying, relating, evaluating, comparing and contrasting, or analysing the physics underpinning the context. This student has demonstrated comprehensive understanding of how principles of physics are relevant to fibre optics. This student has analysed how the principles of total internal reflection and Snell's law are relevant to optical fibres. They have analysed how optical fibres are used to communicate information, including explanations and calculations specifically relevant to the selected context (1). This student has identified, described, and explained how the principles of wave propagation are relevant to modal and chromatic dispersion in optical fibres (2). For a more secure Excellence, the student could: • explain how modal dispersion in optical fibres can be caused by variations in refractive index of the fibre, elaborating on the reasons why these variations are caused • explain how wave dispersion in optical fibres can be caused by the different wave speeds of different frequencies of light in the fibre, elaborating on how this issue can be overcome when using fibres for communication.

Student 1: Low Excellence

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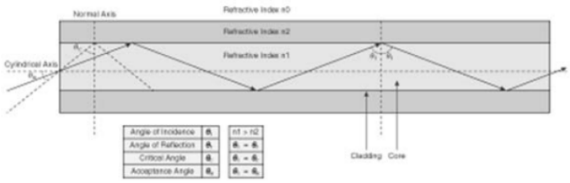
Fiber Optics

Fiber Optics is the study of the design and engineering of optical fiber cables. It is most likely that the last telephone conversation you had, the last TV programme you watched, or your last internet search was because of fiber optic cables. Fiber optics are an intensely physics controlled creation relying on the physics principal pf total internal reflection.

Fiber optics work because of how they are made. The fibers are made of very pure glass and range in diameter but are slightly thicker than a human hair. The fibers are first created by creating a preform blank (which will later be turned into fibers). The preform blank mixture is most important as the precise mixture controls the physical and optical properties of the fiber – including the refractive index. The fibers are tested for things such as refractive index, attenuation, bandwidth and chromatic dispersion. If the fibers pass the tests, the core of the cable is created, which can consist of one or more fibers. The core is then coated in the all-important cladding. Additional layers may be added to prevent light leakage through surface scratches etc. Buffer coating(s) are often added to protect the core and help absorb any shock. A strength member may also be added to protect against pulling/bending damage and environmental factors. All these layers help reduce the amount of attenuation and create a fiber optic cable.



The cables work through the principle of total internal reflection (TIR) which states a ray of light will be 100% reflected when it hits the boundary where a medium of a high refractive index meets a medium of lower refractive index ($n_1 > n_2$), and strikes the boundary at an angle larger than the critical angle ($\Theta_i > \Theta_c$).

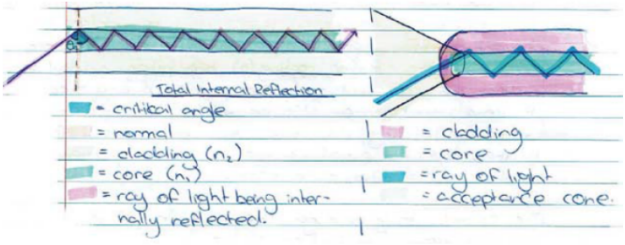
The refractive index is the mediums optical density or the ratio of the speed of light in a vacuum to the speed of light in the material. The core of a fiber optic cable usually has a refractive index of 1.48, therefore the cladding has a lower refractive index. The critical angle means that when the ray of light hits the boundary, it must hit at a certain angle to the normal, so it can travel along the boundary (90° to the normal). TIR occurs when the angle of incidence is larger than this angle. If the angle of incidence is less, some of the light will be refracted (pass through the boundary) and the light will eventually fade off resulting in signal loss.

The critical angle and refractive index (n) is calculated by Snell's law:

$$n_1 \sin\Theta_1 = n_2 \sin\Theta_2$$

For example, for a different fibre optic cable, if $n_1 = 1.557$ and $n_2 = 1.343$, the critical angle is 30.39 degrees. ①

The ray of light must also enter the core at an angle less than the acceptance angle. The acceptance angle is the angle at which if light enters, it will travel down the core. This can also be seen through an acceptance cone which is a core of which the maximum angle of incidence can be to travel down the core. The size of the acceptance cone is a function of the refractive index difference between the core and the cladding.



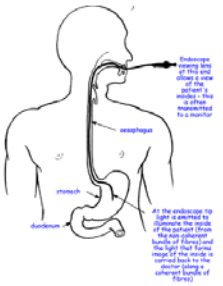
The construction of fiber optic cables will not always enter the core correctly – this results in energy loss of the ray of light or disruption to the light ray. Attenuation is the loss of energy/power in the light ray as it is transmitted down the cable. This can occur due to splices, connectors or faults in the cable. It most commonly occurs because when fiber optic cables are laid, bends in the cable occur. These bends mean the angle at which light hits the boundary is changing and could result in the light hitting the boundary at an angle less than the critical angle. Thus, some of the

light refracts instead of 100% reflecting, and light escapes from the core therefore energy (or signal) is lost. However, this can counteracted by an optical regenerator (explained later in the report).

Dispersion is defined as the spreading of light pulse when they travel a fiber. This is due to the fact that speed of light depends on its wavelength and propagation mode. Dispersion does not weaken the signal, but it blurs the signal. For example, a pulse of 1 nanosecond at the transmitter will be spread out to 10 nanoseconds at the receiver. Hence, signals are not properly received and decoded. Modal dispersion means the light signal is spread over time due to different propagation of light rays in the fiber. Chromatic dispersion is the spreading of the light signal over time due to the different speeds of the different colours of light. Modal dispersion often occurs in multimodal cables. Multimodal have a large core, so the rays internally reflect, and the light signal is often produced by an LED. This light source isn't always the best as light enters the core at different angles, and travels in random lines down the core. The different angles of incidence mean some light rays experience TIR but others experience some refraction and thus signal loss occurs. Chromatic diffusion on the other hand occurs in single modal cables, which have a small core diameter this the light tends to travel in a straight line through the fiber (they can carry more information than multimodal cables). Lasers are usually the light source for single modal fibers, and therefore one wavelength of light travels down the fiber. This one ray of light experiences chromatic dispersion which in turn limits the length of the fiber because the light signal can arrive at the destination all jumbled because it has travelled at different times. (2)

For data to have travelled efficiently, with zero signal loss; the angle of incidence must have always been more than the critical angle, the amount of data sent must be less than the maximum transmission amount over a certain distance and the light must still have enough power to be converted into an electrical signal by an optical receiver (explained later).

The fiber optic cable cannot work by itself, other equipment must be used to transfer the signal. A transmitter is used to produce and encode the light signal by turning an LED/Laser on and off in the correct sequence to create a light signal. The transmitter is found at the start of the link (source) and may have a lens to focus the light into the core (reducing dispersion). Along the link, an optical regenerator may be found to boost the energy of the light ray. It does this as when the light ray comes into contact with a special coating (doping) on the regenerator that is pumped with energy from a laser, the molecules receive that energy and become lasers, thus emitting a stronger signal with the same characteristics as the incoming signal. This reduces the amount of attenuation a light ray may experience. An optical receiver is found at the end of the link (destination) and it receives and decodes the light signal into electrical signal. This occurs as a photocell or photodiode changes the incoming light rays into electrical signals to send to the destination.



Fiber optics has many uses, but an important use is fiber optic imaging. The fiber optic cables act as light pipes because TIR allows 100% of the light to be transferred. The fibers must be arranged in a coherent bundle (fiber placed in same spot in start as they are at the end of the cable) so a mosaic of light forms an image ray the opposite end. An example of this is the medical colonoscopy procedure where one bundle of fibers is used as a torch, and the others act as an elongated lens which sends an image to a video camera or the human eye.

Fiber optics are often preferred over copper wires as they are cheaper, thinner and more light weight. With fiber optics more information can be transmitted as more fibers fit into the same diameter thus more phone lines or TV cables can be wired. There is less signal loss with fiber optics as there is no energy loss due to heat through resistance like in copper cables. Therefore, less power is required. However, fiber optics are hard to join together in small spaces, which in this case copper wires are still preferred (e.g. kitchen appliances). Fiber optics are quicker and easier to repair, suffer minimal propagation delays and have a higher bandwidth so can carry more data. However, some of the light signal degrades within the fibre, mostly due to impurities in the glass. The extent that the signal degrades depends upon the purity of the glass and the wavelength of the transmitted light (for example, 850 nm = 60 to 75 percent/km; 1,300 nm = 50 to 60 percent/km; 1,550 nm is greater than 50 percent/km). Some premium optical fibers show much less signal degradation -- less than 10 percent/km at 1,550 nm.

Overall fiber optics are a brilliant piece of physical design and engineering thanks to the principle of total internal reflection. Even though fiber optics experience signal loss, it can be counteracted, and they are far more efficient than copper cables and sometimes satellite. Fiber optics are a technology that, thanks to Physics, continue to revolutionise data transfer in the world. (2)

	High Merit
2.	For Merit, the student needs to demonstrate in-depth understanding of physics relevant to a selected context. This involves providing reasons as to how or why the physics applies to the selected context. This student has demonstrated in-depth understanding of how principles of physics are relevant to the sport of rowing. This student has explained and analysed how the principles of torques and forces are relevant to the sport of rowing, and explained how moving the position of the pivot has led to improved efficiencies in rowing (1). This student has identified, described and explained how and why the physics concept is relevant to the application. They have by explained how the movement of the centre of mass of a system is relevant to the sport of rowing (2). To reach Excellence, this student could have identified, described, explained and analysed how and why the physics concept is relevant to the application by analysing how the prevention of the relative movement of the centre of mass is relevant to the efficiency of movement of a rowing boat.

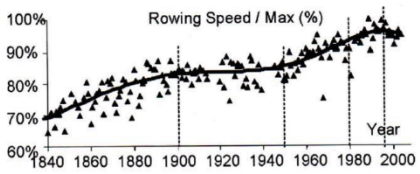
The application of physics in the progressive development of Rowing.

The sport of Rowing has drastically changed over its history and has had several impacts which influence its design, efficiency and the overall competitive edge. In this report, only single person rowing will be explained about (aka as single sculls).

The physics concepts that will be elaborated on are as follows:

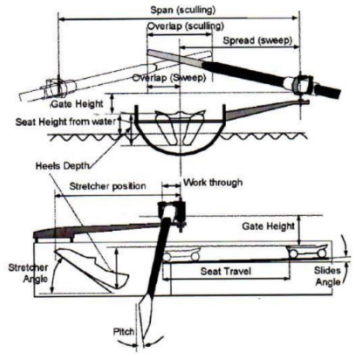
- Forces (in relation to Newtons Three Laws of Motion)
- Energy (kinetic energy)
- Torque

All of these concepts result in a change in the velocity of the boat and can either be better or worse from its initial stage in history.



Before 1900, there was a fast growth rate on which the speed of the rowing boats increased. The reason for this may be explained by the initial development of the equipment used in this sport such as timber boats, outriggers and the sliding seat and also the addition of different sport techniques and different training methods. This fast growth rate slowly decreased between 1900 and 1950 and then increased again between 1960 and 1980. The reason for this is the same as above except, the material used to improve the equipment has changed. Such as instead of timber boats, plastic boats were used, and the oar was changed with the introduction of the big blade. Meaning that the surface area of the end of the oar increased. Then between 1980 and 2000, the growth rate stabilised and the speed in which the boats were travelling has slowly come equal to one another. However, we can further speculate that the other reasons for further development of rowing in our present time are through biological development, such as doping and sociological factors. The above data is based on the Grand Challenge Cup of the Royal Henley Regatta.

Oar structure and boat structure in relation to Torque:



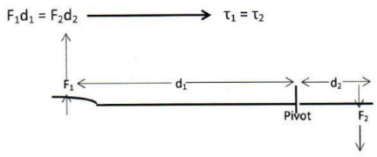
Before we look at the physics concepts behind rowing, we must first look at the structure of the boat and oar. It may look simple, but the mechanics involved aren't because we have to take into account the angle and the movement of the oar as it impacts the water and comes back out. This affects the vector of forces and velocities and hence, the efficiency/effectiveness of the rowing technique.

The diagram on the left shows the parts of the oar and the boat that allows the rower to make the boat accelerate and move forward. The basic maneuver of the oar is a 2-stroke cycle. The first stroke is when the oar impacts the water and the second stroke is when the oar comes out of the water and this 2 stroke cycle repeats. The seat within the boat moves in relation to the 2-stroke cycle of the oar. During the 1st stroke, the seat (human) moves forward while pulling the oar towards the person. During the second stroke, the seat (human) moves backward while pushing the oar away from the person. The oar has 1 centre point each which allows the oar to move along the plane of the boat and can move vertically but only a little. Hence, the physics principle of torque comes into play. Torque is a measure of how much force is acting on an object that causes it to rotate about the pivot point.

The formula for calculating torque is **τ=Fd**

Where τ is for torque, F is the force being applied to the object and d is the total distance between the pivot point and the end of the object.

For oars, there are two forces acting on the oar. When a person is pulling the oar, this end of the oar encounters pulling force while the other end of the oar has water resistance acting on it. When the person is pushing the oar away, this end of the oar encounters pushing force while the other end has water resistance acting on it as it comes out of the water. Therefore, now the formula to calculate the torque for each stroke is as follows;



This formula states that the torque (force) applied on one side on the oar, is equal to the torque (force) that is acting on the opposite side on the oar. The Torque applied is dependent upon the mass of the boat with the person and therefore, by using the formula above, we can calculate the force required by the person if we know the torque that is acting on the end of the oar by the water. E.g.:

$$F_1d_1 = F_2d_2 \longrightarrow 50N \times 1.5m = F_2 \times 0.5m$$
$$F_2 = (50N \times 1.5m)/0.5m = 150N$$

(1)

The relationship between torque, force and distance is that torque is inversely proportional to the distance between the pivot and the person. So, by extending the distance between the pivot and the person, the total torque (force) applied on this end of the oar is decreased significantly. Meaning, that the person now can apply less force but still gain the same velocity and in fact, will be able to gain greater velocity as the person now can oar more efficiently using less energy and less force. (1)

However, this alone is not enough to improve the velocity of the boat. The other physics concept that influences the velocity of the boat is Kinetic energy. Energy is defined as the potential to do work, hence giving us two different forms of energy;

Oar structure and boat structure in relation to Potential Energy and Kinetic/Work Energy.

The reason why only kinetic/work energy influences the torque required to row the boat is because of the boats centre of mass. The boats centre of mass changes as the person moves back and forward on the moving seat. This causes the boat to not be a solid body moving through water. It shakes with the movement of the person.

To improve rowing performance, one method is by reducing the difference in centre of mass during oar strokes which leads to less force acting on the oar and the boat will move faster. The total mass of the system is a constant but the individual masses of boat, oars, and the rower move most of the time relative to each other. The movement of the rower's mass generates an internal force in the system. Rowing best practice is to try to minimize both the distance and speed of movement of the rower to reduce this internal force. The amount the centre of mass changes can be changed by changing the material used to build the boat and the mass of the person. By reducing the difference in centre of mass, the kinetic energy used to move the centre of mass has also decreased and along with it, the force used to row the boat will also decrease.

The result of changing the centre of mass will allow the rower to use less force on the oar which allows the boat to move at a faster velocity. As (2) mentioned in the beginning of the report, the boats have been transformed from wood material to plastic and now fibre glass material. With each transformation of different materials, the physical properties change as well. Wood is a very dense and heavy material, so by having a human in it, it will still float because of the support force of the water but will not be able to move as fast as plastic. The density for plastic is less of that of wood so the likeliness of the boat travelling at a greater velocity than wood is higher. Fibre glass is the current and most modern material that is used for making the rowing boats. It has less density than plastic and has a high tensile strength meaning that of it encounters damage, the chances for major damages is low.

Newton's laws of Motion:

Basically, majority of the information above is related to Newton's Laws of Motion. They are:

1. A body will continue in its current motion unless an external force is applied - The boat will keep moving forward unless an external force is applied, which is the force of water. If the force of the water is greater than the forward force by the boat, then the boat will eventually slow down. Hence, by reducing the mass, the boat is able to travel faster and overcome the water resistance but not completely. The remaining force also has to come from the individual their self.
2. The rate of momentum is directly proportional to the force applied - When the torque is applied on one end of the oar (closest to the person), the other end of the oar (in the water) will have an equal amount of torque. Hence, when the torque (force) applied increases, the total momentums of the boat will also increase. The result will also be that the velocity of the boat increases.
3. Every action has an equal and opposite reaction - as explained for Newton's law number 1, the forward force of the boat will have an equal and opposite force which is water resistance. That is why the forward force of the boat has to be greater than the water resistance in order to gain significant speed.

All of these three laws enable the boat to gain efficiency and hence gain greater velocity during competition. To give rowing the competitive edge, the idea of velocity has to improve in some way shape or form. So, in conclusion, this velocity can be improved in many ways. A few major methods are named in the above report, but in brief summary, these major methods are:

1. Extending the oar between the pivot and the person will allow less torque to be applied and will therefore use less energy and gain greater velocity.
2. Reducing the change in the centre of mass of the boat between strokes.

There are many smaller minor methods that were implemented over the history of rowing as a competitive sport but these are mostly due to biomechanical means. Like, different training techniques and style, different positioning of the oars, etc. These major improvements allowed people all over the world to enhance the sport of rowing and give it the competitive edge.

References:

1. http://www.coachesinfo.com/index.php7option-com content&view-article&id=10139:rowingbiomechanics
2. http://www.atm.ox.ac.Uk/rowing/physics/basics.html#contents
3. http://www.issm.ore/vol7/n4/10/v7n4-10pdf.pdf

All images are from -http://www.coachesinfo.com/index.php?option=com content&view=article&id=10139:rowingbiomechanics&catid-107:rowing-general-articles&Itemid=207

	Low Merit
3.	For Merit, the student needs to demonstrate in-depth understanding of physics relevant to a selected context. This involves providing reasons as to how or why the physics applies to the selected context. This student has demonstrated in-depth understanding of how principles of physics are relevant to car collisions. This student has identified, described and explained how and why the physics concept is relevant to the application by explaining how Newton's first law is relevant to car collisions (1). This student has identified, described and attempted to explain how and why the physics concept is relevant to the application by explaining how impulse is relevant to car collisions (2). This student has identified, described and attempted to explain how and why the physics concept is relevant to the application by explaining how the conservation of energy is relevant to car collisions (3). For a more secure Merit, this student could have identified, described, explained and analysed how and why the physics concept is relevant to the application by: • explaining how impulse relates to the force experienced by a passenger during a car collision • explaining how the conservation of energy relates to the force experienced by a passenger during a car collision.

Student 3: Low Merit

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Physics Internal 2.2

In 2015, Nigel Latta posed the question: ***"If you crash your car, are you better off in a small, modern, 5-star safety rated car or something big and solid?"***

Nigel Latta Blows Stuff Up Series 1/Episode 4: Car Collisions

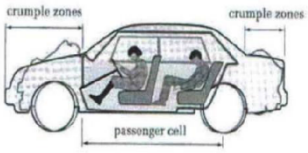
www.tvnz.co.nz/ondemand/nigel-latta-blows-stuff-up/10-05-2015/series-1-episode-4

In this report, I will explain the physics ideas of velocity, Newton's Laws and the law of conservation of energy. I will link them to the situation of car collisions and explain why they are important in this situation.

Sir Isaac Newton discovered three laws that define mechanics.

The First Law:

An object maintains constant velocity (including being stationary) unless acted upon by an external net force.



This is related to car collisions because if the car is moving at 100 km/hr the passengers in the car are also moving at this speed. This means that if the car collides with something and becomes stationary or decreases its speed the passengers in the car will continue to travel at 100 km/hr until acted upon by external force.

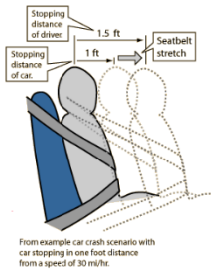
This could be them colliding with something in the car like the windscreen or the seatbelt catching. During a collision, the passengers won't be sharing the same motion state as the car. When a seat belt is not used, the passenger will tend to continue with their state of motion. This law also links to what happens inside the human body during a crash. Once the body has stopped moving all the internal organs continue moving which can cause organs such as the brain to be damaged and sometimes cause fatal injuries such as brain bleeds. This shows that Newton's first Law is important in the situation of car collisions because it shows that if the car doesn't have seat belts and other safety mechanisms the passengers in the vehicle can be seriously harmed. (1)

The Second Law:

If an object experiences an external net force, it will accelerate such that F_{net}= m a.

What this means is that when an object is accelerating it is dependent on two things - the objects net force, and its mass. This law is related to the situation of car collisions because the greater that mass of the car the greater force it takes to accelerate and if the mass of the car stays constant, acceleration increase as the force does. You can calculate the force using the equation F_{net}= m a. For example, if a 1000 kg car accelerates at 0.5m/s/s its force would be 500N (1000 x 0.5).

This links to the situation of car collisions because when two cars are accelerating toward each other the severity of the crash would be dependent on the force of the vehicles and the force is dependent on the mass and acceleration of the car therefore the greater the force of the car the higher chance of fatal injuries to the passengers. In other words, it states that the force that is applied in the collision is proportional to mass of impacting cars. This means that the bigger the force of impacting cars, the bigger the force applied, which implies greater damage. The passengers in the car with the greater mass *should* be better off because it will have a greater force against the other vehicle but because a smaller modern car has safety features this is not always the case.



From example car crash scenario with car stopping in one foot distance from a speed of 30 mi/hr.

The equation of force goes as follows F=ma and a=v/t therefore F=mv/t.

This is relevant because the crumple zone allows more time to be allotted because of its 'crumpling' feature thereby decreasing the force affecting the body of the car and by having a smaller force the car will induce less destruction and decrease the severity of the collision effect towards the passengers. (2)

In terms of collision time, a greater time/stopping distance in the crash will also result in a lower force i.e. *impulse* = $F\Delta t$.

Impulse is the rate of change in momentum.The force acting on the car is inversely proportional to the change in time therefore an increase in time will decrease the force acting on the car and this explains how the crumple zone is effective in reducing the severity of damage to the passengers. (2)

The Third Law:

Any action force has an equal and opposite reaction.

In a car crash Newton's third Law is shown because as the cars collide (actions force) there is an equal and opposite reaction which is the force sent through the cars **in the opposite direction pushing the front of the car backwards and causing** damage to the vehicle. This law is important to the situation of car crashes because the force that is sent backwards can completely crush the car if there are no safety features such as crumple zones and the greater the force of the vehicle the greater the reaction force therefore the faster you go the bigger chance of injury. Injuries such as whiplash are also an example of Newton's third law.

The Law of conservation of energy

The Law of conservation of energy states that energy cannot be created nor destroyed only transformed into another type of energy.

In relation to a car crash when the car is travelling it has kinetic energy using the COE law we know that if the car was in a collision the kinetic energy of the vehicle couldn't be lost nor destroyed only transformed into another kind of energy. This raises the question of what happens to the kinetic energy once the cars have collided? As explained before the energy can be transformed into other energy such as heat and sound energy. Crumple zones is a safety feature of modern cars that are designed to minimize the damage to the passenger's box of the car (behind the windscreen).

Crumple zones in the front of the vehicles minimize damage to the car by absorbing the kinetic energy as stated in Nigel Latta's experiment. COE is important to a collision between two vehicles because the passengers are better off in a vehicle with safety features such as crumple zones that absorb the kinetic energy. (3)

The equation of $V_{average}$= change in distance/change in time can be used to calculate the average speed or velocity. This means that the average speed of an object is calculated by its change in distance over the change in time. We can make the automatic assumption that the faster you are travelling in your vehicle the more damage there will be to your car. This relates to the situation of a car collision because the higher the velocity the more force resulting in more destruction of the vehicle.

In the documentary, the smaller more modern car is a 2013 Toyota Yaris. The Yaris has safety features such as:

- Safety belts that act as the external force to stop the body from moving
- Airbags to stop the passenger hitting the dash board
- Crumple zones to absorb the energy of the car so that the passenger box is unaffected.

In conclusion, the answer to Nigel Latta's question of which vehicle would you be better off in I think you would be better in a modern five-star rating car. I can confirm this through the Physics ideas of Newton's Laws, The Law of Conservation of energy and Velocity. Safety features such as crumple zones, airbags and safety belts minimize the damage to the passengers therefore the mass of the car is defeated by science and technology.

References:

www.tvnz.co.nz/ondemand/nigel-latta-blows-stuff-up/10-05-2015/series-1-episode-4

https://rachelpetrucciano3100.weebly.com/newtons-second-law.html

https://en.wikipedia.org/wiki/Conservation_of_energy

	Grade Boundary: High Achieved
4.	For Achieved, the student needs to demonstrate understanding of physics relevant to a selected context. This involves providing characteristics of, or an account of the physics related to the selected context. This student has demonstrated understanding of how the principles of physics of refraction and lens behaviour are relevant to the correction of impaired vision. This student has identified and described how the thickness of a lens affects the amount of bending, and has attempted to link this to the focal length of the lens. They have used diagrams to show how long-sightedness and short-sightedness can be corrected (1). This student has identified and described how the value of the refractive index is linked to the degree that light is bent inside a lens based upon the material used (2). To reach Merit, this student could have identified, described and explained how the physics concept is relevant to the application by: • explaining why convex lenses refract light to a focal point • explaining how refractive index links to the thickness of lens required.

Student 4: High Achieved

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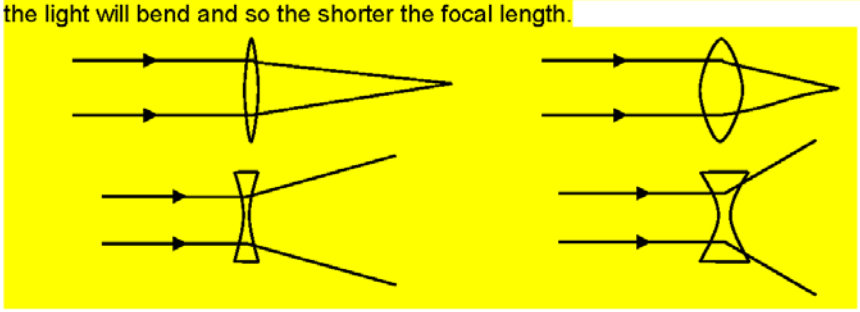
Lenses are transparent objects made normally from glass or plastic. As light travels through the lens, it bends or refracts. Different mediums refract light differently depending on their optical density. This is measured using a refractive index. The higher the RI the more the light bends as it passes into the medium.
For lenses, another factor that changes how much light bends, is the focal length of the lens. Focal length depends on how thick the lens is. For example the thicker a lens is, the more the light will bend and so the shorter the focal length.



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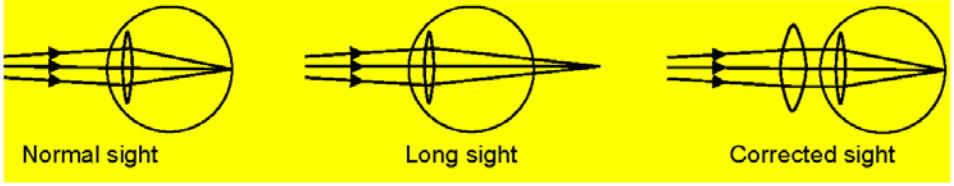
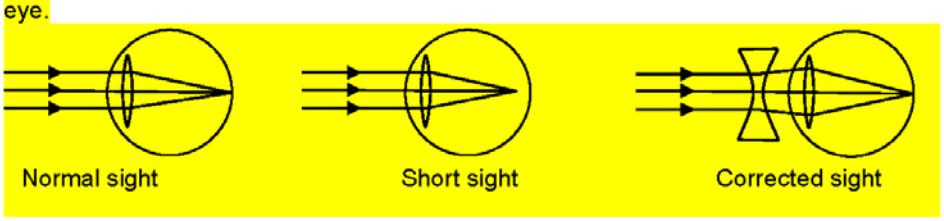
We use lenses all the time in everyday life, in microscopes, telescopes, cameras but most importantly in glasses. Eye glasses are used to correct problems that we can get with our eyes. Long sightedness is when the eye cannot focus on objects close up, so the person can only see long distances. This can be caused by the eye ball being too small, so the image that the eye sees does not fall upon the back of the eye (on the retina) but behind it.

Long sightedness can be corrected by a convex lens, as the convex lens causes the light rays to converge further forward on the retina.



1

Short sightedness is when the eye cannot focus on objects far away so the person can only see short distances. This can be caused by the front of the eye being more curved than round or the eye ball being too long, so the image falls before the retina, rather than on it.
Short sightedness can be corrected by a concave lens, as the concave lens causes the light rays to diverge further before the lens in the eye converges the light rays on the back of the eye.



1

New fluid filled adjustable lenses are now available they are much like normal glasses only the glass lens is replaced with flexible plastic lens with a compartment of silicon oil, and there is an adjustable pump on the side of the glasses.
The pump can pump the silicon oil in and out of the compartment changing the shape of the lens to suit each person's individual eye needs. Silicon oil is used instead of water, as silicone oil has a refractive index (light bending value) of 1.406. This is higher than the light

bending value of some other liquid, such as water (RI of 1.33) Therefore, less silicone oil would be necessary to bend light compared to a larger amount of water. ②

	Grade Boundary: Low Achieved
5.	For Achieved, the student needs to demonstrate understanding of physics relevant to a selected context. This involves providing characteristics of, or an account of the physics related to the selected context. This student has demonstrated understanding of how the principles of physics of refraction and lens behaviour are relevant to the correction of impaired vision. This student has identified and described and explained how a convex lens converges light to a focal point, and has attempted to link this to the focal length of the lens. They have used diagrams to show how long-sightedness and short sightedness can be corrected (1). This student has identified and described and explained how the value of the refractive index is linked to the degree that light is bent inside a lens based upon the material used (2). For a more secure Achieved, this student could: • identify and describe how the thickness of the lens affects the focal point of the lens • identify and describe the significance of refractive index in terms of the focal point of the lens.

Student 5: Low Achieved

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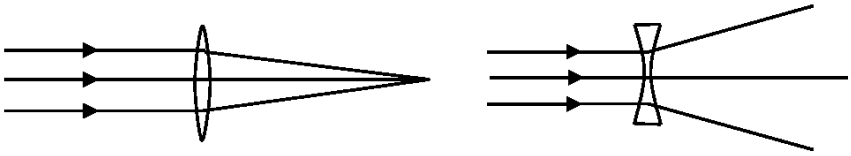
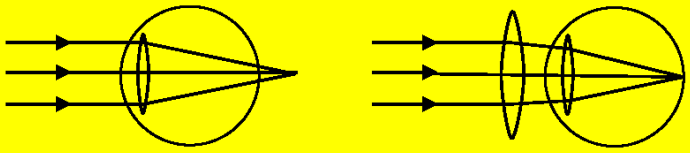
There are two types of lenses convex and concave. Convex lenses are lenses that curve outwards, they converge parallel light rays to a focal point. Concave lenses are thinner in the middle and thicker at their edges. Concave lenses diverge parallel light rays away from each other.



Lenses are able to correct short sightedness because short sightedness is when the light that comes to the convex lens in your eyes converges (meets) at a focal point before your retina. (You can only see an image when the light ray's focal point falls on the retina).

So when you wear glasses they put a concave lens in them which diverges the light rays before they meet the lens in your eye so that when they do converge after going through your lens they converge to a point on your retina and the image is no longer blurry and you can see.

Long sightedness is when the lens converges the light rays but they don't meet on your retina. Instead, if they could. they would come to a point after the retina. And so they use a convex lens to converge the light rays before they reach your eye so then when your eye's lens converges them again the focal point is reached on the retina.



1

It is necessary to pump fluid in and out of the lens to change their shape between concave and convex to become the type of lens that the person needs to be able to see. So for example if they were short sighted the liquid would be pumped out to create a concave lens to help them see.
Silicone was used instead of other substances like water because it is more dense and so it has a higher refractive index. Water has a refractive index of 1.33 whereas silicone is 1.406. This means that the lens doesn't have to be so thick to converge/diverge the light rays to the right extent needed for the person to see [3]. If they used water to fill the lenses they would become thicker and the glasses and flexible membrane would have to be bigger to cater for the larger lens.

2

	Grade Boundary: High Not Achieved
6.	For Achieved, the student needs to demonstrate understanding of physics relevant to a selected context. This involves providing characteristics of, or an account of the physics related to the selected context. This student has discussed the relevance of principles of physics that are relevant to the correction of impaired vision. This student has attempted to describe the physics of how different shaped lenses refract light to different degrees (1) (4). This student has attempted to describe the physics of how lenses can correct sight defects (2) (3). To reach Achieved, the student could: • include appropriate diagrams to describe more clearly how lenses can be used to correct eye defects • define relevant terms such as refractive power • give more detailed descriptions of the physics they are attempting to describe.

Student 6: High Not Achieved

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Our eyes have our own flexible lens. This enables us to change our focus to near or far objects. The lens is surrounded by a ring muscle called the ciliary muscle. This relaxes to allow the lens to contract changing its refractive power. Light is refracted to focus as it passes through the lens (1)

Short sightedness results in blurred distance vision. You will have difficulty looking at distance objects but close objects won't be a problem. People with short-sightedness can see well because when they look into near objects the light gets bent slightly outward. Concave prescription lens are used when you are short sighted because these are used to bend light rays slightly outward. The light ray will be at a greater angle to bend back to focus when it travels through the eye lens (2)

If you are long sighted you will have difficulty seeing objects that are close up. This happens when the length from the front to the back of the eye is too short. Some people have this because the cornea lens does not have enough curvature. Convex lenses are used to treat long sightedness, because they bend light so the retina can focus , and these kinds of lenses are thinner at the edge than at the centre. (3)

Adjustable lenses can change the refractive power. The power of the lens is changed whether you pump in or pump out fluid because it changes the curvature . When fluid is pumped out it reduces the power of the lens and this is suitable for short sightedness and when fluid is pumped in, this increases the power of the lens and this is good for long-sightedness. (4)