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92046

NZQA | Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 1 Physics, Earth and Space Science 2024

92046 Demonstrate understanding of the effect on the Earth of interactions between the Sun and the Earth-Moon system

Credits: Five

ASSESSMENT TASK

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of the effect on the Earth of interactions between the Sun and the Earth-Moon system.	Explain the effect on the Earth of interactions between the Sun and the Earth-Moon system.	Analyse the effect on the Earth of interactions between the Sun and the Earth-Moon system.

Refer to this document to respond to the task for Physics, Earth and Space Science 2024 92046.

Make sure that you have Resource Booklet 92046R.

Check that this document has page 2 and that the page is not blank.

Do not use chatbots, generative AI, or other tools that can automatically generate content.

DO NOT TAKE THESE ASSESSMENT MATERIALS OUT OF THE ASSESSMENT ROOM.

Excellence

TOTAL 21

This report is about how interactions between the Sun and the Earth-Moon system affects Earth. There are three parts that cover three different effects. Use specific evidence from Resource Booklet 92046R and your own knowledge to respond to all parts of the report.

PART ONE: CHANGES IN SHADOW LENGTH IN A DAY

The length and direction of shadows change throughout the day.

Explain why the length and direction of shadows change.

Your explanation should include:

- How the Sun's height changes throughout a day.
- Why the shadows at 9 a.m., midday, 3 p.m., and 6 p.m. have different lengths.
- Why the shadows at 9 a.m., midday, and 3 p.m. have different directions.
- Why Auckland and Invercargill have different shadow lengths during the same day.

PART TWO: SEASONAL CHANGES BETWEEN CHRISTCHURCH AND SCOTT BASE

Many research scientists fly out from Christchurch Airport to research stations such as Scott Base in Antarctica. These two places experience different day lengths in different seasons.

Explain why there are seasonal changes between Christchurch and Scott Base.

Your explanation should include:

- How the tilt of the Earth creates differences in day length between the seasons.
- The differences between equinoxes and solstices.
- How the Sun's path appears to change throughout the year.
- Why daylengths are different between Christchurch and Scott Base throughout the year.

PART THREE: ECLIPSES

Explain the conditions necessary to observe **solar** and **lunar eclipses** using the figures provided in the resource booklet as needed.

Your explanation should include:

- The relative positions of the Sun, Moon, and Earth during solar and lunar eclipses.
- The relevant phases of the Moon for solar and lunar eclipses.
- Why solar and lunar eclipses do not occur every month.
- Why a lunar eclipse lasts longer than a solar eclipse.

Lil Level 1 Physics, Earth and Space Science 2024

Part 1. Shadows change direction and length throughout the day.
The Sun rises in the east and sets in the west each day. As the Earth rotates, the Sun appears to move in the sky. Due to the Earth's rotation, if you were to plant a tree in mid New Zealand it would receive varying heights and amounts of sunlight over the course of a day. Refer to figure 1, part 1, for visual representation.
At the beginning of the day, as the sun begins to 'rise', the Earth would be rotating on its axis, and the Sun's light rays would begin to hit the tree. At first the Sun would appear to be low in the sky, as the Earth is only just rotating into a position that allows light to be cast over the tree. As the Sun is appearing low in the sky, the angle that the light rays are hitting the tree at are flat. This causes the shadow that it casts to be long, as the tree is blocking more sunlight and shadows are the absence of light.
As time throughout the day goes on however, the length of this shadow would decrease, and then later increase again. This is because as the Earth continues its rotation, the sun would begin to cast light onto more of New Zealand, and at a sharper angle. The Sun would be facing New Zealand (and the tree) more directly, meaning its light rays would be covering less surface area, and making the light and heat more intense. This would mean that the light rays emitted from the Sun would be on a straighter angle, so the tree would be blocking less sunlight, as it is coming from more above, than across like in the mornings. This would mean the shadow cast would be shorter than the mornings.
As the day gets later, the tree's shadow would begin to get longer again. This is because the Earth is rotating to a position that makes the Sun appear west in the sky, and at a flatter angle like in the morning. This would mean that the light rays emitted from the Sun would be on a flatter angle once more, and the tree would block more sunlight, casting a longer shadow.

At 9 am, the Sun would appear low in the sky as it is close to sunrise, and would be emitting sunlight at a flat angle. The tree would then be casting a long shadow because of this.
At midday, the Earth will have rotated further, and the Sun will appear higher in the sky. The sunlight at this time will be the most intense due to covering less surface area, and the tree will cast a shorter shadow as the Sun is more directly above.
At 3 pm, the shadow will be starting to lengthen again, as the Earth rotates, and the Sun appears lower in the sky. It will still be shorter than at 9 am, but the sunrays will be at a flatter angle towards the tree than at midday, so the sunlight blocked will be more, and the shadow casted will be longer.
At 6 pm, the shadow will be very long, as it is close to sunset. The Sun will appear very low in the sky, as the Earth has rotated to a position where the Sun is casting light on the tree from the west at a flat angle. The tree will be blocking lots of light due to this, hence why the shadow will be so long. In winter, there wouldn't be a shadow as it would already be dark, but in this I refer to summertime.

The shadows will also be cast in different directions as the day goes on (refer to drawing 1 for visual representation). This is because as the Earth rotates, the Sun appears to move across the sky, moving from east to west. This means that the sunlight is being cast on the tree from different directions as the day goes on. In the morning (9 am) the Sun's rays are hitting the tree from the east, so the light is being blocked in the west - creating a western shadow.
At midday, the Sun appears to be in a more northern position in the sky, so the tree will be blocking light heading to the south, hence casting a southern shadow.
In the afternoon (3 pm) the Sun will appear to be in the west of the sky, so the light that the sun emits will be hitting the tree from the west, and the tree will block the light going to the east. This means it will cast an eastern shadow.

Auckland is closer to the equator than Invercargill. This means that it is facing the Sun more directly all year round. Because of this, the Sun's rays hit Auckland from higher above then in the more southern place of Invercargill. As Auckland is receiving sunlight from more directly above, the shadows casted are not as long, as not so much sunlight is being blocked. In Invercargill however, the Sun hits the town from a lower angle, as the Sun appears lower in Invercargill's sky. This means that the shadows casted are longer as more light is being blocked. This can be backed up by looking at table 1, part 1, as it tells us that the Auckland tree casts a shadow that is 19 metres shorter than the same sized tree in Invercargill.

Part 2. There are seasonal changes between Christchurch and Scott Base.
Because the Earth is on a tilt of about 23.5 degrees relative to its orbit around the Sun, there is a lot of variation in the day lengths, meaning that the hours of sunlight change. When a hemisphere is experiencing summer, the days are longer than that same hemisphere in winter. This is because in summer, the hemisphere is at the part of Earth's orbit where it's tilted towards the sun. This means that the Sun is more directly in line with the hemisphere, so as the Earth rotates each day, the hemisphere that's facing the Sun takes longer to move out of its light, as it's tilted towards it.
In drawing 3, you can see that the Northern Hemisphere is tilted towards the Sun, and is therefore experiencing summer. The Sun would be appearing high in the sky over this period. Due to being tilted this way, the sunlight is hitting it more directly and it takes longer for the Earth to rotate into a position where sunlight is not reaching countries in this hemisphere. This means that over the course of a day, northern countries will receive more daytime, as they are receiving sunlight for a long period of time before rotating out of position.
The Southern Hemisphere in drawing 3 is experiencing winter. It is tilted away from the Sun, and is therefore getting hit with less direct and intense sunlight. For the counties in this hemisphere, the Sun would be appearing lower in the sky, and daylight hours would be shorter compared to the Northern Hemisphere. The Earth would have tilted the countries into a position that receives sunlight for less hours as it would take longer in the Earth's daily rotation to be facing the Sun in a direction that allows these downward facing countries to receive sunlight. This is why they receive less daylight hours compared to the Northern Hemisphere.
In Spring and Autumn, daylight hours are reasonably equal for both hemispheres, as they are tilted neither towards or away from the Sun.

The Earth is on a tilt of about 23.5 degrees relative to its orbit around the Sun.
A solstice occurs when one of the poles is at its maximum tilt either towards or away from the Sun. When this happens whatever pole that's tilting towards the sun will have the longest day and shortest night of the year. This is called the 'Summer Solstice". The other pole, which is tilted at its maximum tilt away from the Sun, experiences its 'Winter Solstice', where it's the shortest day and longest night. There are two Solstices per year on each hemisphere, and they happen at the same time, just opposite ones are occurring.
An equinox occurs when the Sun is perpendicular to the Equator. It causes the day and night to be equal time, and this event occurs twice annually.
Solstices and Equinoxes both happen happen twice a year. As shown in figure 1, part 2, the solstices occur during June and December, which is winter and summer. The equinoxes occur during March and September, which is spring and autumn.

The Sun's path appears to change throughout the year as the Earth is on a tilt of about 23.5 degrees relative to its orbit. This means that as the Earth orbits around the Sun, different regions of the planet are tilted towards and away from the star. When a region of Earth is in

summer, it is at the part of the orbit where that region is tilted toward the Sun. This causes the Sun to appear more directly overhead. When that same region is experiencing winter, it is tilted away from the Sun, and therefore the Sun appears lower in the sky, and sunlight hits the region at a flatter angle.
In figure 2, part 2, you can see A, B, C heights of the Sun. A would occur during winter, as the Sun appears lower in the sky. In reality, the Earth is actually tilting this region away from the Sun, so the sunlight hitting it comes from a lower, flatter angle. B would occur during spring and autumn, as the Sun is moderately positioned in the sky, appearing not high but not low. In reality the Earth would be tilting this region equally away and towards the Sun in its orbit, causing the sunlight to hit it from a moderate height and angle. C would occur during summer, as the Sun is appearing high in the sky, at noon almost directly above. This would be the result of the region being tilted towards the Sun, making the sunlight hit it from a high angle.

Christchurch is closer to the Equator than Scott Base (Antarctica), which is much closer to the South Pole. Because of this, the places receive different amounts of sunlight year round in comparison to each other. Referring to table 1, part 2, we can see that when the biannual equinox occurs, both places have 12 hours of daylight. This is where the similarities end. When the Southern Hemisphere has its summer solstice, Scott Base has a day of full sunlight, whereas Christchurch only receives 15 hours and 25 minutes. This is because Scott base is very close to the South pole, and the Southern Hemisphere's summer solstice occurs when the South Pole is at its maximum tilt towards the Sun. Due to Scott Base being so near to the South Pole, it is heavily tilted towards the Sun, so much so that even as Earth makes its daily rotation, the Base never becomes positioned away from the Sun. This causes it to receive sunlight for a full day, during the summer solstice.
In Christchurch, it doesn't receive a full 24 hours of sunlight because it's higher up from the South Pole. This means that it is still in a position where when the Earth makes its daily rotation, it will eventually spin away from the Sun and no longer receive sunlight. It will then go into night.

During the winter solstice, the opposite of this occurs. Scott Base receives zero hours of sunlight during this event, as it is so close to the South Pole, which at this time will be at its maximum tilt away from the Sun. This means that even as the Earth makes its rotation, the Base will not be put into a position that can receive sunlight. It is therefore cast into darkness and has zero hours of sunlight.
Christchurch has 8 hours and 56 minutes of daytime during the winter solstice however. This is due to it being further from the South Pole that is tilting towards the Sun than Scott Base is. It is still in a position to receive sunlight because of this, and as the Earth rotates, the city is cast into sunlight that is from a Sun that appears very low in the sky. The sunlight wouldn't be very intense during this time, but Christchurch will still be receiving daytime, unlike Scott Base.
Refer to drawing 4 for visual representation of the last 2 paragraphs.

Over spring and autumn, the day lengths at these two places will be similar, and at equinox, as previously mentioned, they will both be receiving the same amount of daytime - 12 hours.

Part 3. For an eclipse to occur, near perfect alignment between the Earth, Moon, and Sun is required. The order of this alignment decides what type of eclipse it is. A lunar eclipse occurs when the Earth is positioned in between the Sun and Moon, and the planet blocks sunlight, casting a shadow and blocking the Moon. A solar eclipse is when the Moon is in between the Earth and Sun, and it blocks the sunlight from illuminating the Earth, casting part of the Earth into shadow. Refer to drawing 2 for visual representation.

For a solar eclipse to occur, there must be a new moon. As you can see in the first diagram of figure 1, part 3, the Sun is positioned behind the Moon, and the Earth is in front. As the Moon is in front of the sun, it blocks the light that would be travelling to Earth, and casts shadow upon the planet. Because the Moon is smaller than the Earth, not all of Earth is in darkness during a solar eclipse. There are two parts - the umbra and the penumbra. The umbra is the region cast most deeply into darkness and shadow. It is in direct positioning behind the Moon. The penumbra is the area surrounding the umbra, and is still within the shadow, but not as dark. Sunlight may still be slightly visible to those within the penumbral region, but it will be partially obscured, so therefore darker than usual. For a partial eclipse to occur, the alignment between the Earth, Moon, and Sun is slightly off, causing the Earth to be only partially obscured, and generally only be within the penumbra of the Moon's shadow. During a full eclipse however, the alignment must be very close to perfect, and the Earth will have a region that is positioned within the umbra, and enveloped in complete darkness.

For a lunar eclipse to occur, there must be a full moon. The Moon must be positioned behind the Earth, and the Sun must be positioned in front. You can see this in the second diagram of figure 1, part 3.
Due to the Earth being larger than the moon, the shadow it casts has the ability to fully obscure any sunlight heading for the Moon. If there is perfect alignment between all three celestial bodies, the Moon is able to fit into the umbra region that the Earth's shadow creates, and a full lunar eclipse will occur. The Moon would be completely invisible from the Earth in this scenario. Surrounding the Moon is the penumbral region. If the alignment between the Earth, Moon, and Sun is not quite right, the Moon may only be positioned within the penumbra of the shadow. This would cause a partial eclipse - the more common eclipse - and the Moon may still be visible from some parts of Earth.

Eclipses do not occur monthly even though new and full moons do. This is because the Moon is orbiting the Earth on a 5 degree tilt relative to the Earth's orbit around the Sun, so it is more often than not too high or low to align with the Sun and Earth. So it isn't often cast into shadow, or casting one itself. This means that even when it is a full or new moon, the Moon often won't be in the correct position to fulfil the necessary alignment.
Solar eclipses are more rare than lunar eclipses as the alignment has to be much more accurate. There are generally multiple lunar eclipses a year, but only 1 solar eclipse every 18 months because of the unlikeliness of the near perfect alignment occurring. It is even less likely to have a full eclipse than a partial, as the alignment between the 3 celestial bodies must be very precise.

Lunar eclipses last longer than Solar because the Earth is much larger than the Moon. As shown in table 1, part 3, a solar eclipse only lasts 4 minutes, whereas a lunar eclipse lasts 3 hours. This is because the Earth is larger than the Moon, so it casts a far larger shadow than the surface area of the Moon it is covering. The Moon will therefore be in darkness for longer as it takes more time for it to leave the umbra and penumbra of the shadow, and become unaligned.
The Moon casts not only a smaller shadow, but the Earth is much larger. This means that alignment for a solar eclipse must be near perfect, and as soon as it is not, the umbra and penumbra of the shadow will stop obscuring the sunlight heading towards Earth, and it will no longer be in shadow.

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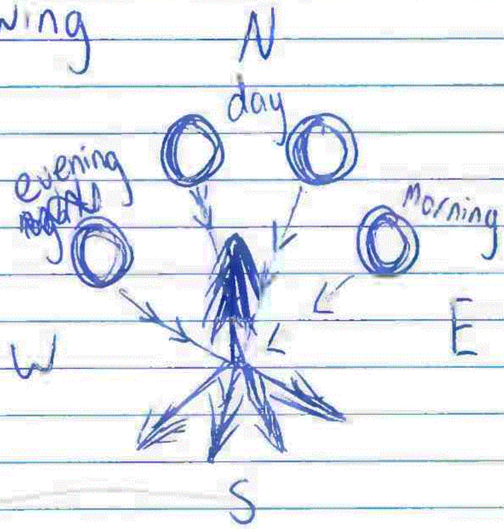
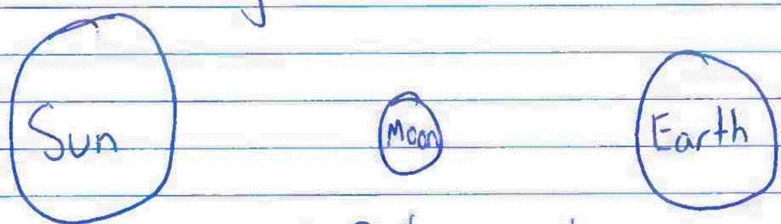
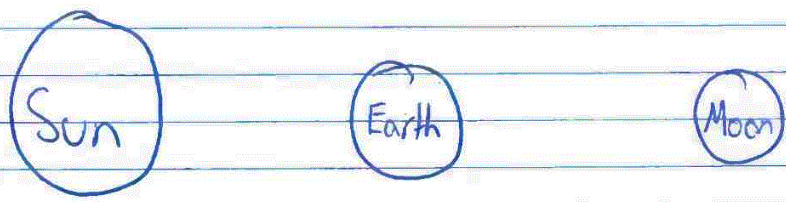
Drawing 1



Drawing 2



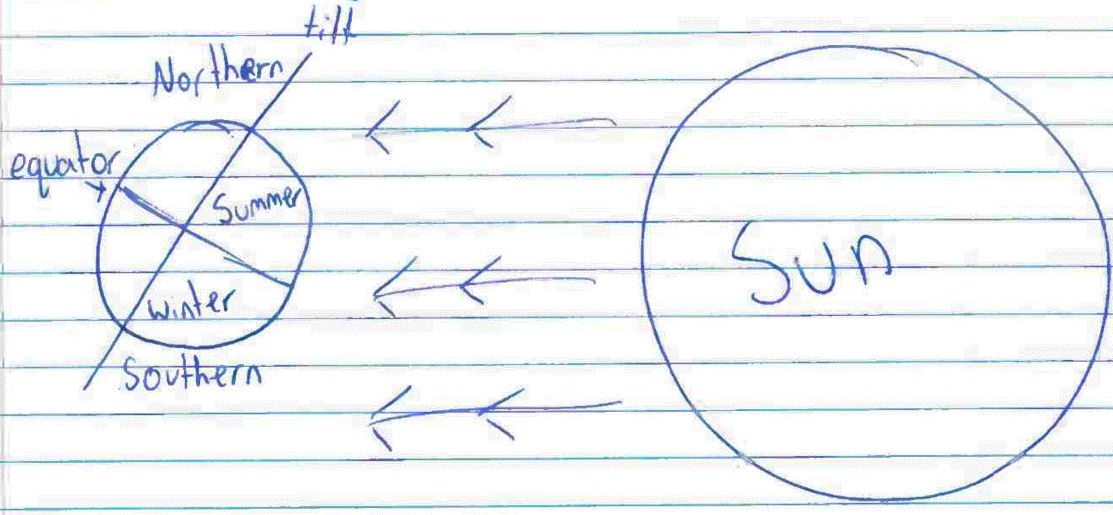
= Solar eclipse

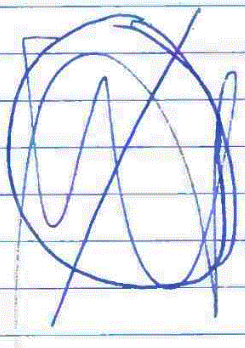


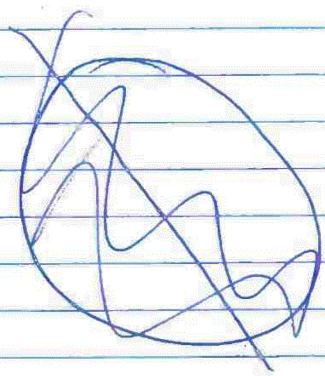
= Lunar eclipse

3 LJ

Drawing 3







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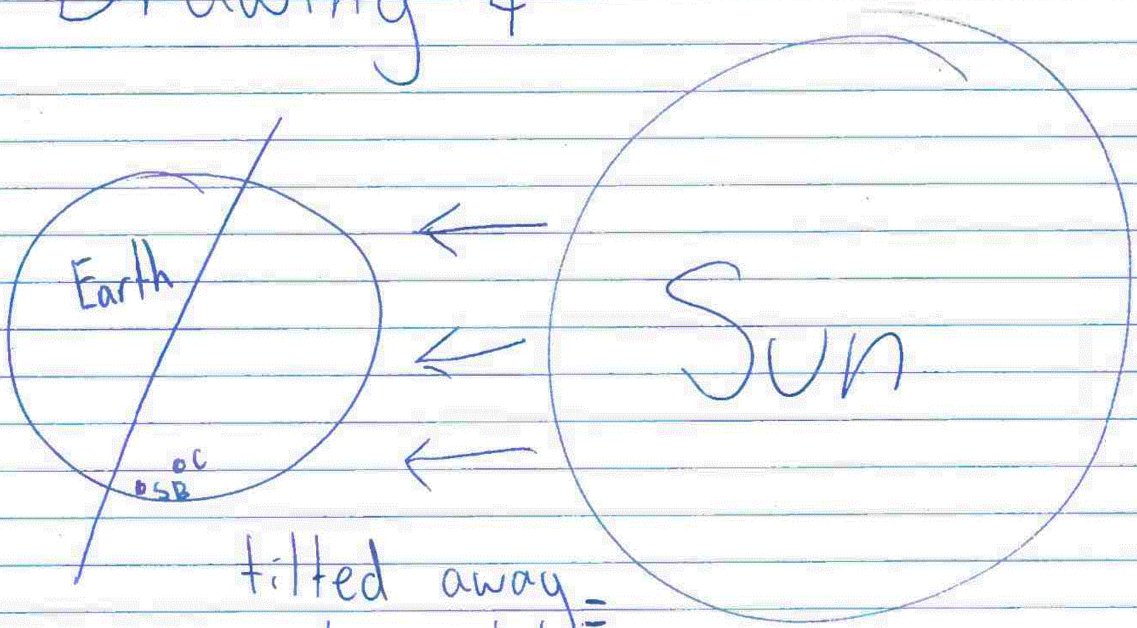
Drawing 4



tilted away = winter solstice

tilted towards = Summer solstice

Excellence

Subject: Physics, Earth and Space Science

Standard: 92046

Total score: 21

Q	Grade score	Marker commentary
One	7	Candidate has discussed why Invercargill has longer shadows than Auckland by linking it to latitude. However, they have not discussed how the length of day changes throughout the year.
Two	7	Candidate has discussed why the daylength between Scott Base and Christchurch **is different** linking it to the tilt of the Earth as well as differences in latitude. However, they did not discuss how the seasons are different between these two locations.
Three	7	Candidate has discussed why a lunar eclipse lasts longer than a solar eclipse. However, they haven't fully discussed how the angle of the Moon's tilt means that we don't experience a lunar or solar eclipse every month.