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92046Q

Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 1 Physics and ESS RAS 2023

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

Credits: Five

PILOT ASSESSMENT

ASSESSMENT TASK

Check that this booklet has pages 3–6 in the correct order and that none of these pages is blank.

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 the resources and your own knowledge to answer all parts of the report.

PART ONE: LUNAR PHASES

In a lunar month, the Moon passes through different phases.

Discuss the different phases of the moon shown in the Resource Book.

In your answer, you should explain:

- Why we see these different phases of the Moon.
- Why the lunar cycle (new moon to new moon) takes 29.5 days.
- Why the Moon rises at different times each day.

PART TWO: TIDES

From time-to-time Aotearoa / New Zealand experiences king tides (perigean spring tides) in addition to the normal high and low tide cycle.

Discuss the different types of tides experienced in Aotearoa / New Zealand.

In your answer you should explain:

- How normal high and low tides form.
- Why two high and two low tides occur every day.
- Why spring and neap tides occur every 14 days. Refer to the data in the table.
- Why Aotearoa / New Zealand experiences king tides (perigean spring tides) at irregular intervals of time.

PART THREE: SEASONS

Aotearoa / New Zealand experiences four seasons every year – spring, summer, autumn, winter – whereas other parts of the Earth do not.

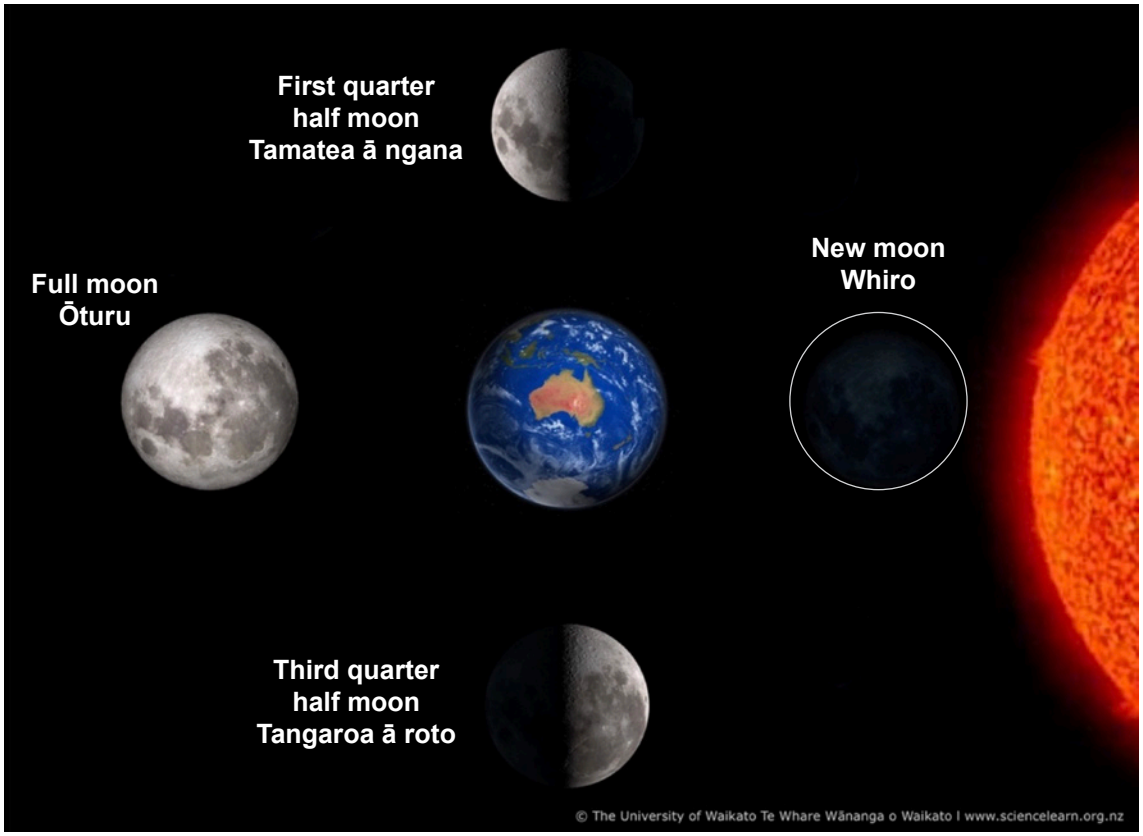
Discuss how seasons vary across the Earth.

In your answer you should explain:

- Why Aotearoa / NZ experiences four different seasons.
- Why the United Kingdom in the Northern Hemisphere experiences the same four seasons, but at different times of the year.
- Why the Equator experiences little seasonal variation compared to Aotearoa / New Zealand.

PART ONE: LUNAR PHASES

Figure 1: Lunar Phases Southern Hemisphere



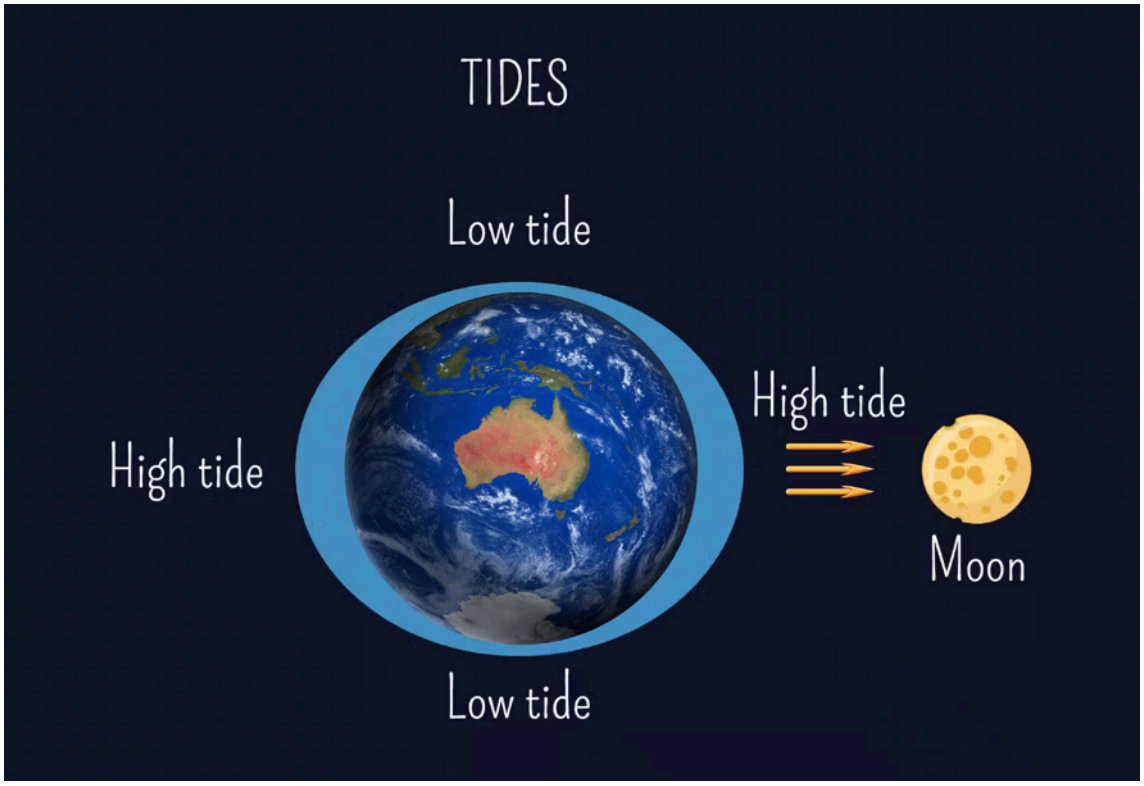
Adapted from: www.sciencelearn.org.nz/images/684-moon-phases-from-the-southern-hemisphere

Table 1: Moonrise times for four consecutive days in Aotearoa/New Zealand

Date	18 July 2023	19 July 2023	20 July 2023	21 July 2023
Time	07:59 AM	08:37AM	09:08 AM	09:35 AM

PART TWO: TIDES

Figure 2: Tides

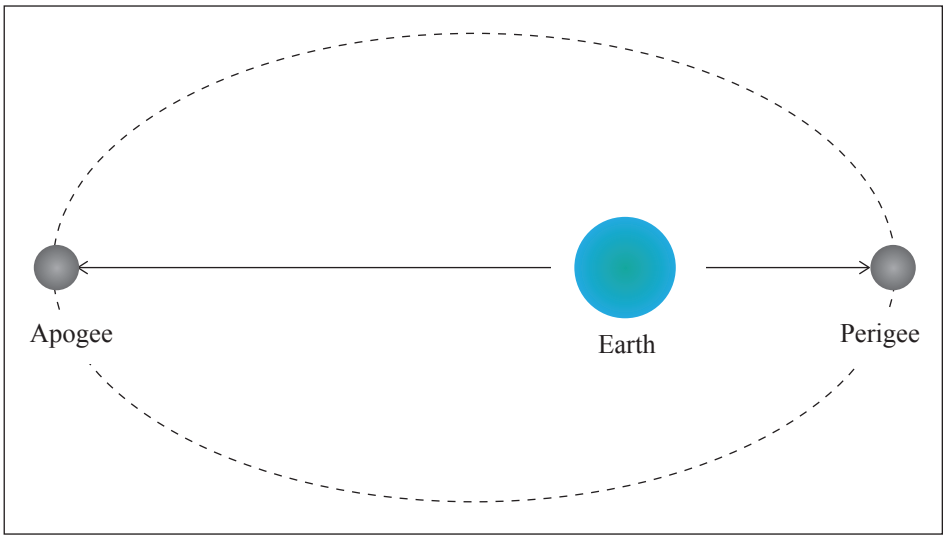


Adapted from: www.tigermarinecharter.com/tides-where-does-the-water-go-when-the-tides-go-out/

Table 2: Time between tides

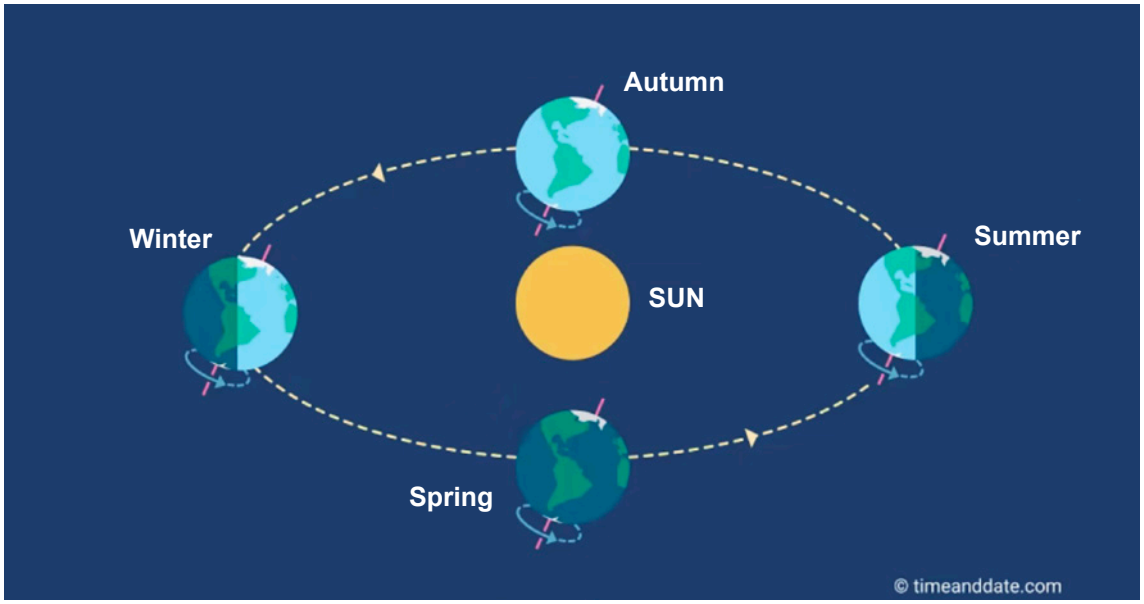
Type of tide	Time between times
High	12 hours 25 minutes
Spring	14–17 days
Neap	14–17 days
King (perigean spring tide)	Approx. 7 months

Figure 3: The Moon's orbit



PART THREE: SEASONS

Figure 4: The Earth's Orbit



Adapted from: www.timeanddate.com/calendar/aboutseasons.html/

Seasons indicated are for the Southern Hemisphere.

Figure 5: World map showing New Zealand and the United Kingdom

Adapted from: https://worldmapblank.com/labeled-map-of-world/

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

EXEMPLAR

Achievement

TOTAL 10

PART ONE: LUNAR PHASES

We see different phases of the moon because the moon orbits the earth and as it does so we see the same surface of the moon with different amounts of lit area on the surface. As the moon travels between the sun and earth we see a new moon because the sun is hitting on the side of the moon turned away from us. As it travels around earth we start to see a part of the moon and into the first quarter. Then as it travels behind earth, now earth is between the moon and the sun we see a full moon. This is because the surface where we see is now facing the sun and can be lit by it. The moon keeps moving and the lit area from where we can see it becomes smaller and smaller until it becomes a new moon again. This whole process takes 29.5 days, because it is how long the moon takes to orbit the earth. The moon rotates its axis that stays on the same tilt once as it orbits the earth once, and we always see the nearside of the moon. The earth stays at a tilt all the time, however as the moon orbits, earth would be tilted differently towards the moon, away from it or at small differences in between. Therefore the moon would rise at different times each day because it would be around different areas of the earth's tilt. Also the moon moves east everyday and it would take the earth's rotation a little longer until it catches up and we can see the moon. So it would look like the moon rises a little later each day. If all the months were 29.5 days long, then on the same day each month the moon would rise at the same time.

PART TWO: TIDES

The moon has gravity that pulls on the earth, it creates tidal bulges on both sides of earth. The tidal bulge on the opposite side is caused because of the centrifugal force. At the same time the moon has gravity pull on the earth, the sun also does. When the moon and sun are lined the combined force is very large and causes a spring tide. When the moon and sun are at a 90 degree angle the combined force is weaker and this is a neap tide. The height of the daily tides change over a month because the moon is moving and the distance from the sun is different.

A king tide is a very large spring tide, it occurs when the moon is at a perigee where it is closest to earth. Spring tides and neap tides happen every 14-17 days because the moon is moving and the height of the wave depends on the position of the earth, moon and sun. We experience two high tides and two low tides everyday because of the rotation of the earth, and there are two high tides and two low tides caused by the moon's gravity and centrifugal force. As the earth rotates during a day we turn around once experiencing the low and high tides. New Zealand experiences king tides on irregular intervals of time because king tides are very rare and only happen when the moon is at a perigee and is inline with the sun, this is very hard to happen and because our latitude is slightly larger on earth so it happens at irregular intervals for us.

PART THREE: SEASONS

Some parts of the earth experience four seasons and some don't, Antarctica only has two seasons because it is either tilted away or towards the sun and doesn't have much difference in between. However New Zealand has four seasons because we have a smaller latitude and experience more tilt differences as we move around the sun and so NewZealnd experiences sunlight all year round. As the earth orbits the sun it's tilt stays 23.5 degrees all year round. We are in summer when we are tilted towards the sun and receive more direct sunlight and therefore have warmer temperatures. As our earth rotates and we are tilted away from it, receiving sunlight on a more tilted angle, the temperature is lower because the energy is spread across a larger area. This is when autumn comes for us. When we completely tilt away from the sun it is winter, as we keep moving around the sun we start to tilt back towards the sun and it is spring, when we completely turn towards the sun it becomes summer again.

The United Kingdom experiences the same four seasons at different times of the year compared to us because they are in the northern hemisphere, while we are in the southern hemisphere. This means when we are tilted towards the sun they are tilted away from the sun and therefore we experience different seasons at different times.

The earth had the same tilt all year round. The equator experiences little seasonal difference because as the earth rotates the sun they stay in the middle and don't experience much tilt difference when turning away or towards the sun, compared to New Zealand which has a larger latitude and experiences more tilt difference along the year.

Achievement

Subject: Physics, Earth and Space Science RAS

Standard: 92046

Total score: 10

Q	Grade score	Marker commentary
One	A3	Candidate has identified that Moon's orbit around the Earth causes phases, why new moon to new moon takes 29.5 days and positions of moon and sun for three phases of the moon.
Two	A3	Candidate has defined perigee and apogee as well as why spring and neap tides occur at 14–17 day intervals.
Three	A4	Candidate has described that the seasons are caused by Earth's tilt and orbit, temperature variation being smaller at the equator and that summer and winter occur at different times.

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Level 1 Physics, Earth and Space Science RAS 2023

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

EXEMPLAR

Merit

TOTAL 15

PART ONE: LUNAR PHASES

The Moon has 8 different phases and they are caused because the Moon orbits around the Earth, and this causes different parts of the Moon to appear to be lit up by the Sun. There are two sides of the Moon and we can only see one of them (half). The near side which is the one we can see, and the far side which is the other half of the Moon you cannot see from Earth. The far side of the moon is only visible if you go to space. We only see one side of the Moon because the Moon rotates at the same speed it rotates around the Earth. There are four main Lunar Phases in the Southern Hemisphere starting with the New Moon, then it goes to the First quarter half Moon, Full Moon, Third Quarter Half Moon and it goes back to the New Moon, and the cycle restarts after every 29.5 days. The New Moon is fully dark, so it is not very visible from Earth because there isn't enough sunlight to light it up, however, sometimes you are able to see an outer line around the New Moon and that happens because the sunlight that is reflecting off Earth reflects on the Moon, different from the Full Moon that is fully lit by the sunlight. The first and the third quarter half Moon, as the name says, only half of the Moon is lit up. The lunar cycle takes 29.5 due to the Earth's orbit around the Sun. It takes 29.5 for the Sun to be aligned with the Moon and the sunlight to hit the Moon the same way it did on the first day of those 29.5 days. The Moon rises at different times each day because it depends on where the Moon is relative to the Earth and the Sun and that will determine when the Moon will rise everyday, and that is why sometimes the Moon rises earlier or later.

PART TWO: TIDES

Tides happen because of the gravitational pull of the Earth which causes the tides to either be high or low. There are two main different types of tides, Neap tide and Spring tide, and they both occur every 14-17 days. This occurs when the Moon's tidal bulge is aligned with the Sun's tidal bulge. Spring tides occur during a full moon or new moon, neap tides occur during a first quarter half moon or a third quarter half moon. Neap tide occurs when the Moon is 90 degrees to the Sun, which then causes the pull of the Moon and Sun to be weak causing the tides to be low, and they happen during a spring tide. Neap tides cause high tides to be lower than usual and low tides to be higher than usual. Spring tides occur when the Moon and the Sun are in the same direction. When spring tides occur, high and low tides become stronger or weaker than usual. High tides get higher and low tides get lower, and this causes a large tidal range. Everyday two low tides and two high tides occur, and this is because the Earth rotates through two tidal bulges in a lunar day. King tides is the other type of tide, New Zealand experiences king tides at irregular intervals of time because king tides only occur when the Moon is at its perigee phase (they only happen approximately between 7 months) which means that it is when it is closest to the Earth. When the Moon is closer to the Earth the tides tend to get higher, and that is what king tides are. King tides are stronger than spring tides, and this is because the Moon is closer to Earth during a king tide than it is during a spring tide.

PART THREE: SEASONS

There are four seasons, spring, summer, autumn and winter, and depending on where you are in the World you might experience them at different times of the year. This happens because of the Earth's tilted axis.
New Zealand experiences four different seasons because of the Earth's tilted axis, throughout the year New Zealand might experience these four seasons because of the Earth's orbit around the Sun. The Sun always hits different parts of the Earth, this means that if the Sun is hitting the Southern Hemisphere (where we are) it will be summer for us, meaning that the days will be longer. If the Sun is hitting away from the Southern Hemisphere, it will be winter for us, and the days will be shorter. And this cycle continues to happen every year.
In the Northern Hemisphere, the United Kingdom experiences the same four seasons however at different times of the year. This happens because of the Earth's tilted axis being tilted with respect to its orbital plane, so when the Southern Hemisphere is facing the Sun, the Northern Hemisphere is obviously facing away from the Sun, and as the Earth orbits around the Sun, the Northern Hemisphere will experience Summer, for example, at a different time of the year.
The Equator experiences little seasonal variation compared to New Zealand because of the angle of the Sun that is directly facing the Equator. This causes the areas around the Equator such as most of South America, to be hotter than most places around Earth.
In conclusion, seasons occur because of the tilt of Earth's axis.

Merit

Subject: Physics, Earth and Space Science RAS

Standard: 92046

Total score: 15

Q	Grade score	Marker commentary
One	A4	Good point about seeing one side of the moon, describes the phases, doesn't explain the positions of the Earth-Moon and Sun for the different phases of the moon.
Two	M6	Would have got Achievement with Excellence if they had explained high and low tide formation; candidate has explained why New Zealand experiences king tide, spring, and neap tide.
Three	M5	Candidate has explained why the two hemispheres have seasons at opposite times.

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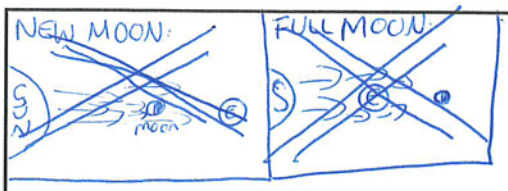
92046 Demonstrate understanding of the effect on the Earth of interactions between the Sun and the Earth-Moon system

EXEMPLAR

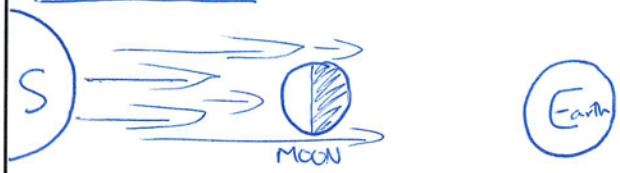
Excellence TOTAL 19

PART ONE: LUNAR PHASES

One side of the moon is always lit by the suns light. As the moon orbits the earth, we on earth see different parts of the lit side. This is why we see phases of the moon. For example, when it is a new moon, the moon is in between the earth and the sun, so the side of the moon which is lit by the sun is facing away from us on earth. This means we can not see the lit side, and that is called a new moon because on earth we can't see any of the moon because the side facing us is not lit up. During a full moon the earth is in between the sun and moon. Sunlight goes around the earth and lights up the side of the moon which is facing us on earth. Because we can see the full side of the ~~earth~~ moon lit up, this is called a full moon. When the moon is at the first quarter and third quarter points of its orbit, the sun and moon are at right angles to the earth. This means from on earth we can only see half of the lit side which is facing the sun. That is how we have half moons in the phases of the moon: because we can only see half of the lit side of the moon.
The lunar cycle takes 29.5 days because this is how long it takes ~~to orbit the~~ for the moon to orbit the earth once. ~~So from the time there is a new moon, and then the moon has gone through~~ The moons phases are caused by its orbit around the earth, and one orbit takes 29.5 days, so this is how long it takes for the lunar cycle.
The moon rises at different times each day depending on which phase it is in, and depending on its orbit and earths rotation. These factors cause it to rise at different times.



NEW MOON:



FULL MOON:

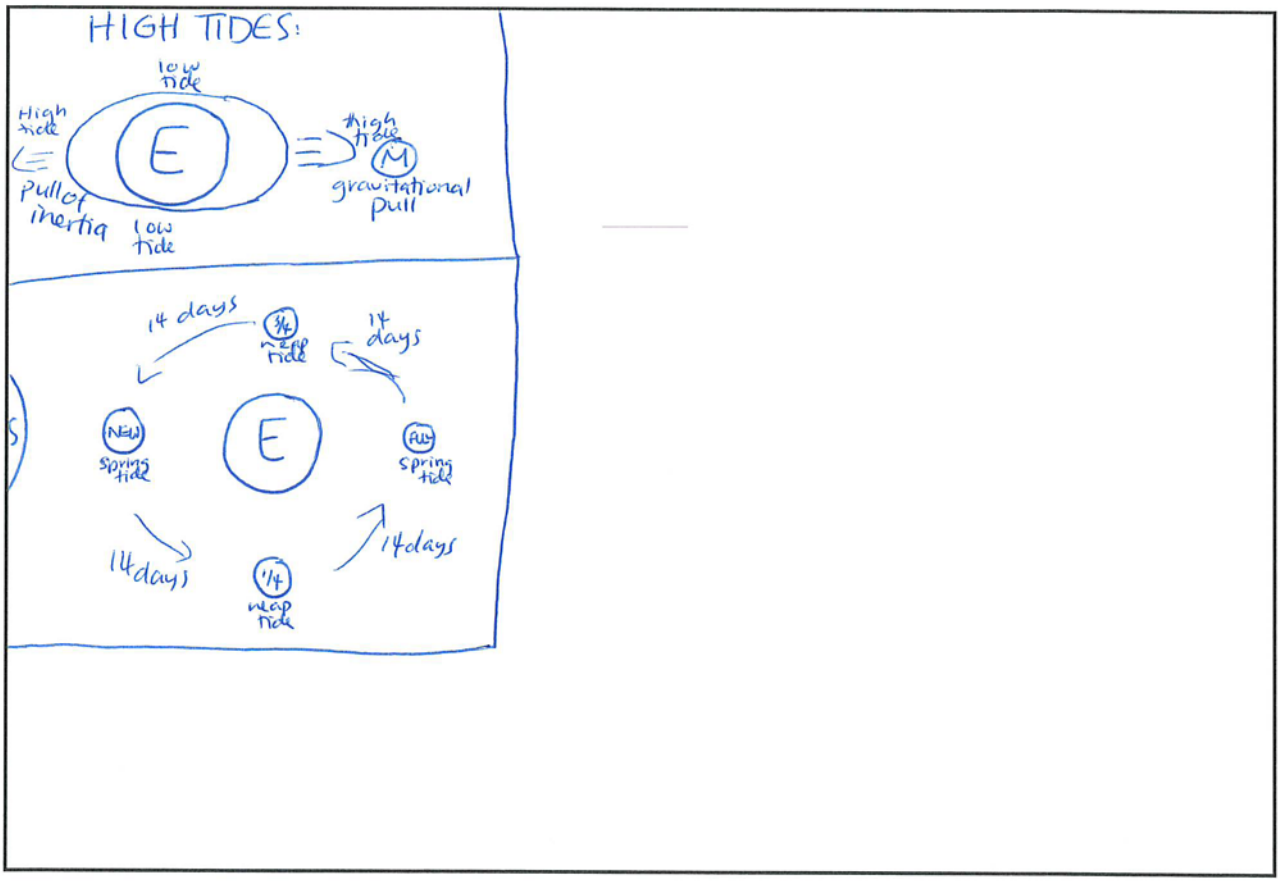
PART TWO: TIDES

Tides are caused by the sun and moons gravitational pull on the earth. High tides are caused twice a day ~~by~~ and they occur when the area is in the tidal bulge. The tidal bulge is caused by ~~the~~ the moon's gravitational pull on one side of the earth, and the pull of inertia ~~which~~ on the opposite side of the earth. So the side of the earth facing the moon, and the opposite side which is facing away have the high tide, and the other two sides have low tide. Because of the earths rotation, there is always two high tides in a day: ~~when in the gravita~~ once from the gravitational pull of the moon (when facing the moon), and once from the pull of inertia (when facing away from the moon). In between the two high tides there is low tides.

A spring tide occurs when the sun, moon, and earth are in alignment, and the gravitational pull of the sun and moon combined causes the highest high tides and the lowest low tides.

A neap tide occurs when the moon is at first-quarter or third-quarter, and the sun and moon are at 90° angles to each other which causes the gravitational pull from each to partly cancel out each others effect. This results in moderate tides where the difference between high ~~low~~ and low is the least. Spring tides and neap tides occur every 14 days because this is the time between the four moon phases when these tides occur. There is 14 days between (each phase:) new moon, first quarter, ~~third quarter, and~~ full moon, and third quarter.

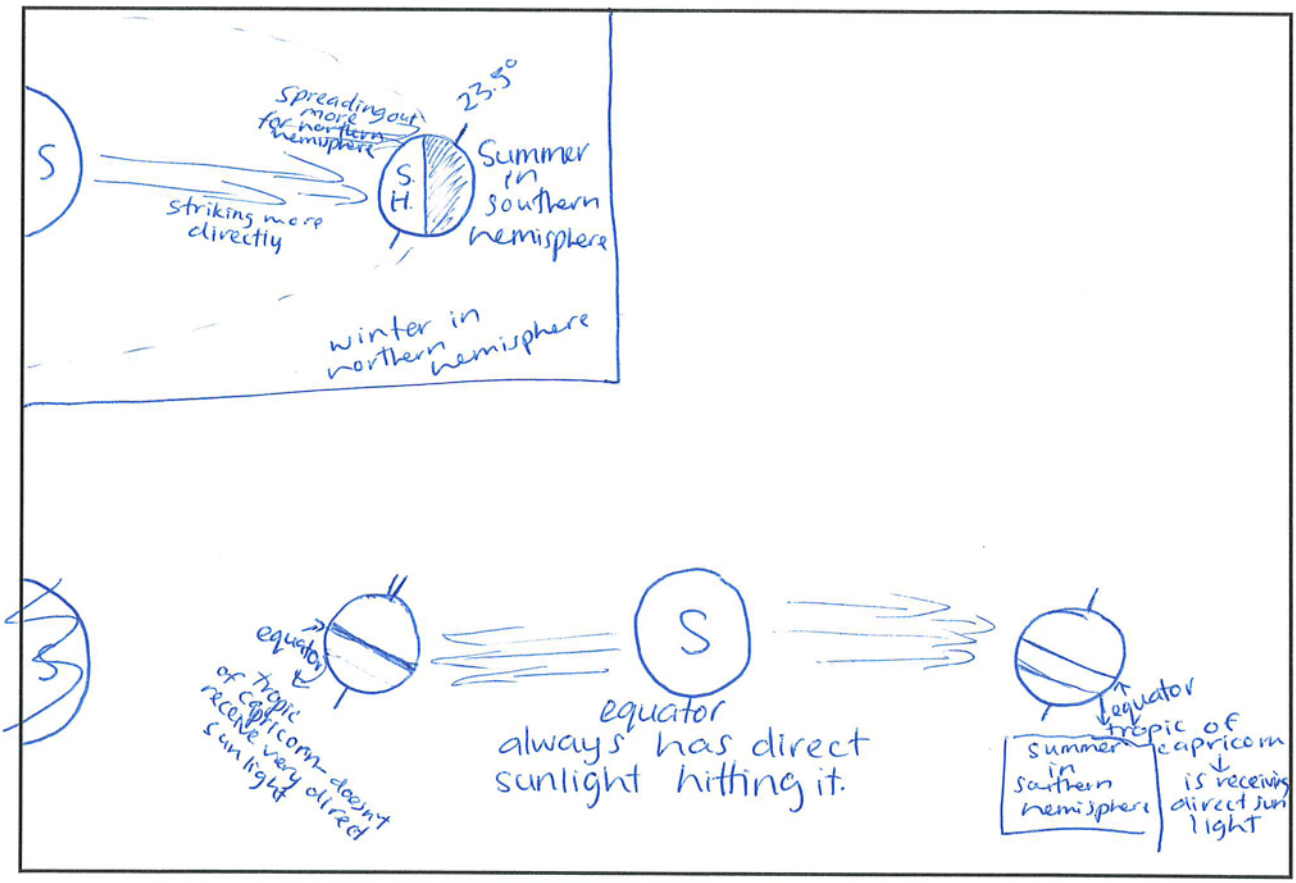
A king tide is a spring tide when the moon is at its perigree, which means it is at the point of its orbit when it is closest to earth. New Zealand experiences king tides at irregular intervals because ~~it~~ it has to be both a new or full moon and the moon must be at its perigree for this to happen, and because of the slight tilt (5°) in the moons orbit, both things don't occur at the same time regularly. That is why the intervals



between king tides occuring are irregular.

PART THREE: SEASONS

Seasons on earth are caused because of the earths tilt as it orbits the sun. The earth is tilted 23.5° on its axis which causes one hemisphere to be facing the sun more than the other. This is what causes the seasons in the two hemispheres. Summer in New Zealand occurs when the southern hemisphere is tilted towards the sun. When it is tilted towards the sun it means the angle of insolation is smaller, meaning that the suns rays are hitting the earth at a more direct angle. When the sunlight is striking at a more direct angle it means it is spreading over less area which makes the energy more concentrated, therefore increasing the temperature. And that is how summer is caused. Winter is the opposite. In winter, the southern hemisphere is tilted away from the sun, which means that the angle of insolation is larger. This means that the sun rays are hitting the southern hemisphere less directly and is spreading over a larger area; more m^2. This means that the sunlight (energy) is less concentrated which lowers the temperatures, causing winter. In between summer and winter the southern hemisphere is neither tilted at or away from the sun, which results in middling temperatures (in spring & autumn). The United Kingdom is in the northern hemisphere which means that although they have the same seasons as the southern hemisphere, they have them at opposite times of the year. This is because when the southern hemisphere is tilted towards the sun, meaning we have summer - the northern hemisphere is tilted away from the sun, which means the energy hitting them is hitting at a lower angle and is spreading out, which lessens the concentration of energy and lowers the temperature. Winter. Again, when we have winter, pointing away from the sun - they are tilted towards it and have summer. That is why the United Kingdom in the northern hemisphere has opposite seasons



to New Zealand in the southern hemisphere. The equator is in the middle of the earth which means it receives the most direct sunlight of any point on earth. Because it is in the middle, there will always be almost direct sunlight hitting it, whether the southern hemisphere is ~~facing~~ tilted towards the sun or whether the northern hemisphere is. ~~That is why the equator~~ In contrast, NZ is down the bottom of the earth in the southern hemisphere on the Tropic of Capricorn. This means that it only receives direct sunlight (or more direct sunlight) ~~in the~~ when the southern hemisphere is tilted towards the earth. That is why the equator experiences little seasonal variation compared to New Zealand.

Excellence

Subject: Physics, Earth and Space Science RAS

Standard: 92046

Total score: 19

Q	Grade score	Marker commentary
One	M5	Candidate has explained two phases of moons in terms of their relative positions of Earth-Moon-Sun system.
Two	E7	Candidate has discussed why Aotearoa/NZ experiences king tides at irregular intervals.
Three	E7	Candidate has discussed how the relationship between Earth and Sun in terms of orbit and tilt can cause variation in radiation and seasons.

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New Zealand Qualifications Authority

Level 1 Physics, Earth and Space Science RAS 2023

92047 Demonstrate understanding of energy in a physical system

EXEMPLAR

Achievement TOTAL 10

You may find the following formulae useful.

$$E_k = \frac{1}{2}mv^2 \qquad \Delta E_p = mg\Delta h \qquad g = 10 \text{ N kg}^{-1} \qquad W = Fd$$

$$E(\text{thermal}) = mc\Delta T \qquad E(\text{thermal}) = mL$$

$$P = VI \qquad V = RI \qquad \Delta E = P\Delta t$$

QUESTION ONE

Jamie plays with his football while he waits for his bus. He throws the ball vertically up. The ball has a mass of 0.150 kg and reaches a height of 3.4 m. As it falls back down, its speed just before it hits the ground is 7.8 m s^{-1}.

(a) In the box below, write an equation to show the energy changes taking place when the ball falls back down from its highest point.

gravitational pot. → kinetic energy + heat energy

(b) Calculate the size of the average force of friction between ball and air.

Begin your answer by showing that, on its way down from the highest point, 0.537 J of mechanical energy are changed into other forms of energy.

E = 0.537J

m = 0.150kg

h = 3.4m

v = 7.8ms^{-1}

$E_k = \frac{1}{2}mv^2$

$= \frac{1}{2} \times (0.150) \times (7.8)$

$E_k = 0.585$

$E_p = mg\Delta h$

$E_p = 0.150 \times 10 \times 3.4$

$= 5.1$ J

$W = Fd$

$F = \frac{W}{d}$

$F = \frac{0.537}{3.4} = F = 0.158$N

(c) While falling, 80% of the 0.537 J converted to other types of energy is absorbed by the ball. The specific heat capacity of the ball is 8200 J kg^{-1} $°C^{-1}$.

Calculate the rise in temperature of the ball as it falls.

$E = mc\Delta T \quad \Delta T = \frac{E}{mc}$

$T = \frac{0.537}{(0.150 \times 8200)}$

$T = 0°C$

(d) After some time, Jamie's bus did not arrive. Jamie shoulders his backpack and walks to the train station. On his way to the platform, he climbs a flight of stairs.

In terms of work and/or energy, explain why each of the following three statements given below is true.

No calculations are needed.

(i) (ii) (iii)

work done/ is time taken to do work.

(i) No work is done on Jamie's backpack when Jamie is standing at the bus stop.

True. Jamie is shouldering his backpack. That takes energy for Jamie. The backpack is hanging from his shoulders but not moving.

(ii) No work is done on Jamie's backpack when Jamie walks at constant speed on horizontal ground.

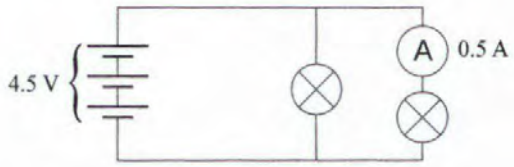
False. Jamie is in motion at constant speed. The person's energy is being used up. So the backpack is moving with Jamie.

(iii) Work is done on Jamie's backpack when Jamie climbs up a flight of stairs.

True. Jamie's backpack is moving as he climbs the stairs. It bounces off his back.

QUESTION TWO

Jake has a torch that uses three 1.5 V batteries in series. The torch has two lamps, each rated at 4.5 V, connected as shown in the circuit diagram below. The current through each lamp is 0.50 A.



(a) Calculate the resistance of each lamp.

$V = RI$ $\quad R = \frac{4.5}{0.50}$ $\quad R = 9\ \Omega$

$\frac{V}{I} = R$

(b) The batteries power both lamps simultaneously.

Explain why both lamps glow with their rated brightness if connected as shown above.

Begin your answer by identifying what type of connection the above diagram shows.

This is a parallel circuit where the current for the lamp is used up in different paths. If the lamps were placed in the same path of the circuit, the light would be dimmer as the current has to be shared. But since its parallel, the light lamps will be brighter but the batteries will be finished faster.

(c) Calculate the amount of electrical energy used by both lamps in two hours.

Begin your answer by calculating the power output of each lamp.

$P = VI$

$P = (4.5 \times 0.50)$

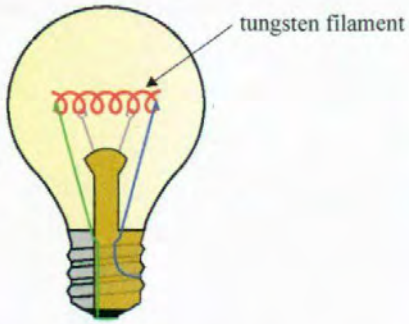
Power output of each lamp = 2.25W

$\Delta E = P\Delta t$ $\quad (2 \times 60 \times 60 = 7200\ sec)$

$\Delta E = (2.25 \times 7200)$

$E = 16200\ J$

(d) Jake's torch uses incandescent lamps. These lamps have a very thin tungsten wire called a 'filament'. When a current passes through such a filament, it heats up and glows.



Tungsten is a metal with a very high melting point and a relatively small specific heat capacity. The very small diameter of the filament means that the filament has a large resistance.

Explain why the high melting point, small specific heat capacity, and large resistance of the filament are important for the incandescent lamps to work well in a circuit.

Begin your answer by describing the energy changes that occur in the filament when a current passes through it.

chemical → electrical → heat
→ light
→ sound

Incandescent lamps works well with high melting point, small specific heat capacity and large resistance in the filament. With large resistance due to small diameter in the filament, too much current won't be used up but will shine bright. Saves electricity. The filament turns chemical energy into electrical and then converts to thermal energy to heat it up and make it glow with light energy and due to that, sound energy will be produced. This lamp won't finish fast and lasts longer because of small specific heat capacity and large resistance.

QUESTION THREE

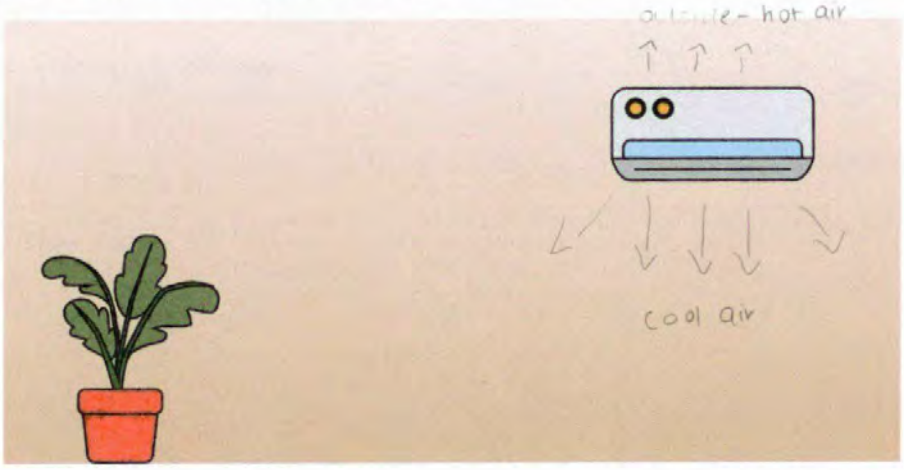
Pearl has had an air conditioning (AC) unit installed in her room. The AC unit uses electricity to cool down air and blow cooled-down air into her room. This way, Pearl's room is comfortably cool although it is hot outside.

AC units are typically mounted high up on a wall.

https://flitemechanical.com/mini-split/

(a) In the diagram below, draw labelled arrows to show the movement of warm air and cool air in the room.

Disregard effects of air being pushed out of the AC unit.

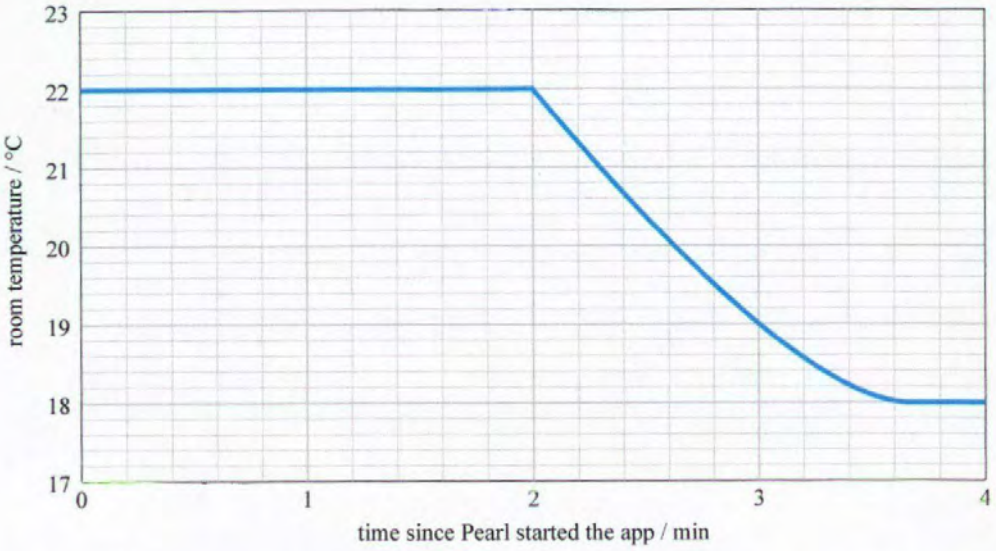


(b) The volume of space occupied by a given amount of air depends on the temperature of the air. This is the reason for the movement of warmer and cooler air around the room.

Explain, in terms of particle theory of matter, why a given amount of cooler air occupies a slightly smaller volume of space than the same mass of warmer air.

Warmer air usually stays at the top. When warmer air takes over a space, the cooler air moves away. Volume of space occupied by air depends on the temperature of air. Since air is gas, the particles can be moved freely unlike solid & liquid and are not bonded. Warm air holds more weight than cool air.

(c) One summer morning, Pearl checks the room temperature on her phone. Two minutes after she starts the app, she sets the AC unit to 18 °C and switches it on. The temperature in her room drops as shown in the graph below.



Pearl's room contains 41.4 kg of dry air; the specific heat capacity of dry air is 718 J kg^{-1} °C^{-1}.

Using information from the graph above, **calculate the average power** of the AC unit in the two minutes after Pearl sets it to 18 °C.

Begin your answer by calculating the amount of thermal energy drawn from the air in Pearl's room.

$E = mc\Delta T$

$E = (41.4) \times (718) \times (18)$

E (thermal) $= 535053.6$ J

$\frac{E}{\Delta t} = \frac{P\Delta t}{\Delta t}$

$\frac{E}{t} = P$

$(2 \times 60) = 120$ sec

$P = \frac{535053.6}{120}$

Average $P = 4458.78$ W

Question Three continues on the following page.

(d) At night, when it gets cold outside, Pearl closes the curtains on the window in her room. Pearl's curtains reach down to the floor and are close to the wall.

Explain why the layer of air between the curtain and the window reduces heat transfer by conduction through the glass of the window pane.

In your answer, you should:

- explain, in terms of particle theory of matter, how heat transfer by conduction works
- compare and contrast conduction through air and glass.

Conduction is a way of heat transfer. Cool air usually moves to spaces with more volume. Since there is not much space between the wall and the curtain, heat energy is transferred. Warm air particles is not bonded. Conduction through air and glass. Heat energy from air transfers to glass, making it warmer. Glass is usually cold. Air makes glass warmer

Achievement

Subject: Physics, Earth and Space Science RAS

Standard: 92047

Total score: 10

Q	Grade score	Marker commentary
One	A3	• Correct description of energy transfers. • Correct calculation of the average friction force without the required difference between KE and GPE. • Correct formula selected but inferred final value and no accounting for only 80% of the energy going to heat. • Unable to explain or analyse the energy changes in the given context. No recognition of $W = Fd$ or valid changes in energy.
Two	A4	• Correct use of $V = IR$ and change of subject to find R. • Correct identification of the circuit type but explanation to justify the same level of brightness – the same PD across both bulbs. • Correct power for a single lamp and then conversion of time into seconds to give a correct energy for a single lamp. • Correct description of the energy changes in a filament lightbulb. Incorrect explanation or analysis of why the given features of a filament lightbulb are important to its function.
Three	A3	• Demonstrates understanding of convection. • Demonstrates understanding of low bonding between gas particles compared with solids and liquids. No explanation of relative energy of particles at different temperatures. • Correct formulae selections and conversion of minutes to seconds but incorrect change in temperature.

Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 1 Physics, Earth and Space Science RAS 2023

92047 Demonstrate understanding of energy in a physical system

EXEMPLAR

Merit TOTAL 16

You may find the following formulae useful.

$$E_k = \frac{1}{2}mv^2 \qquad \Delta E_p = mg\Delta h \qquad g = 10\ \text{N kg}^{-1} \qquad W = Fd$$

$$E(\text{thermal}) = mc\Delta T \qquad E(\text{thermal}) = mL$$

$$P = VI \qquad V = RI \qquad \Delta E = P\Delta t$$

QUESTION ONE

Jamie plays with his football while he waits for his bus. He throws the ball vertically up. The ball has a mass of 0.150 kg and reaches a height of 3.4 m. As it falls back down, its speed just before it hits the ground is 7.8 m s^{-1}.

(a) In the box below, write an equation to show the energy changes taking place when the ball falls back down from its highest point.

Gravitational Potential Energy → Kinetic Energy + Mechanical Energy

(b) Calculate the size of the average force of friction between ball and air.

Begin your answer by showing that, on its way down from the highest point, 0.537 J of mechanical energy are changed into other forms of energy.

$E_P = mg\Delta h$, $m = 0.150$ kg, $g = 10$ N, $\Delta h = 3.4$ m, $E_P = 0.150 \times 10 \times 3.4$, $E_P = 5.1$ J

$E_K = \frac{1}{2}mv^2$, $m = 0.150$ kg, $v = 7.8\text{ms}^{-1}$, $E_K = \frac{1}{2} \times 0.150 \times 7.8^2$, $E_K = 4.563$ J,

$E_P - E_K = 5.1 - 4.563$, $= 0.537$ J of mechanical is changed into other forms of energy as gravitational potential energy changes to kinetic energy on the way down from the highest point the ball reaches,

Forces acting on the soccer ball are unbalanced - soccer ball is accelerating, weight force greater than force of gravity.

(c) While falling, 80% of the 0.537 J converted to other types of energy is absorbed by the ball. The specific heat capacity of the ball is 8200 J kg^{-1} °C^{-1}.

Calculate the rise in temperature of the ball as it falls.

$E = mc\Delta t$, $E = 0.537\,J$, $m = 0.150\,kg$, $c = 8200\,Jkg^{-1}$, $\Delta t = ?$, $0.537 = 0.150 \times 8200 \times \Delta t$

$\Delta t = \frac{mc}{E}$, $\Delta t = \frac{0.150 \times 8200}{0.537}$, $\Delta t = \frac{E}{mc}$, $\Delta t = \frac{0.537}{0.150 \times 8200}$, $\Delta t = \frac{0.537}{1230}$

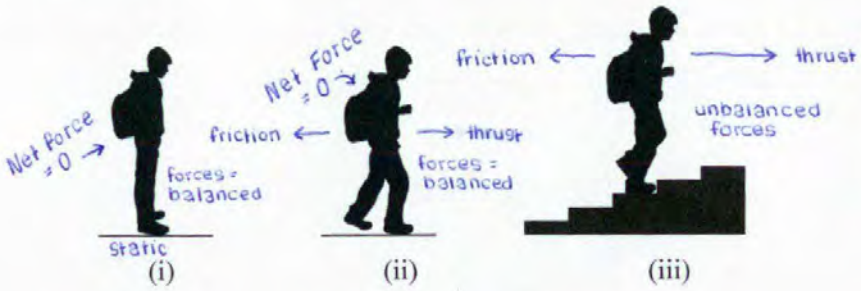
$\Delta t = 0.00044°C$

The rise in temperature as the ball falls is 0.0004°C.

(d) After some time, Jamie's bus did not arrive. Jamie shoulders his backpack and walks to the train station. On his way to the platform, he climbs a flight of stairs.

In terms of work and/or energy, explain why each of the following three statements given below is true.

No calculations are needed.



(i) No work is done on Jamie's backpack when Jamie is standing at the bus stop.

No work is done because Jamie is standing still - as he is not moving, so or the backpack is not moving so no energy is required, because he is not doing and work. - he is static, net force is 0, forces acting on Jamie are balanced

(ii) No work is done on Jamie's backpack when Jamie walks at constant speed on horizontal ground.

No work is done because at a constant speed, friction and thrust acting on Jamie are equal (opposite forces are equal), meaning forces acting on Jamie are balanced, so his net force is 0,

(iii) Work is done on Jamie's backpack when Jamie climbs up a flight of stairs.

Work is done because Jamie is moving, so energy is required to climb the flight of stairs, increased mass of Jamie (including mass of backpack) = increased amount of work needed to be done to climb the flight of stairs, thrust is greater force than friction, forces are unbalanced net force = greater than 0 Jamie is accelerating

QUESTION TWO

Jake has a torch that uses three 1.5 V batteries in series. The torch has two lamps, each rated at 4.5 V, connected as shown in the circuit diagram below. The current through each lamp is 0.50 A.

(a) Calculate the resistance of each lamp.

$V = RI$, $V = 4.5V$, $R = ?$, $I = 0.5$, $4.5 = R \times 0.5$, $R = V/I$

$R = \frac{4.5}{0.5}$, $R = 9$, Resistance of each lamp is $9\ \Omega$

(b) The batteries power both lamps simultaneously.

Explain why both lamps glow with their rated brightness if connected as shown above.

Begin your answer by identifying what type of connection the above diagram shows.

This diagram is a parallel ~~series~~ circuit meaning that there is more than one route for the current (flow of electrons) to go. In a parallel circuit, if one component ~~(lamp 1~~ (lamp 2 in jakes case) breaks, the circuit will still work because there is more than one route for the current to take. In a parallel circuit, there is increased current, so increased ~~function.~~ less resistance. Both lamps glow with their rated brightness when connected through a parallel circuit because of how the function of the circuit increases when the current increases, ~~so~~ allowing for both lamps to glow with their rated brightness of 4.5V each. - ~~so~~ there isn't as much resistance acting against the current (flow of electrons).

(c) Calculate the amount of electrical energy used by both lamps in two hours.

Begin your answer by calculating the power output of each lamp.

$P = VI$, ~~P=~~ $V = 4.5$, $I = 0.5$, $P = 4.5 \times 0.5$, $P = 2.25\ W$

$\Delta E = P\Delta t$, $P = 2.25w$, $\Delta t = 2h$, ~~$\Delta t = 2.25 \times 2$, $\Delta E = 4.5J$~~ 2h in min = 120

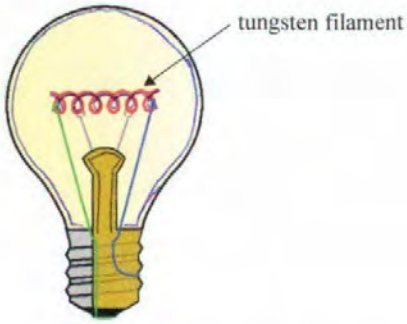
$\Delta t = 120$, $\Delta E = 2.25 \times 120$, $\Delta E = 270J$

~~Electrical energy used by both lamps in 2 hours is 4.5J each.~~

Electrical energy used by both lamps in 2 hours is **270J each**

$(270 \times 2 = 540)$, Total electrical energy = **540J in 2 hours.**

(d) Jake's torch uses incandescent lamps. These lamps have a very thin tungsten wire called a 'filament'. When a current passes through such a filament, it heats up and glows.



Tungsten is a metal with a very high melting point and a relatively small specific heat capacity. The very small diameter of the filament means that the filament has a large resistance.

Explain why the high melting point, small specific heat capacity, and large resistance of the filament are important for the incandescent lamps to work well in a circuit.

Begin your answer by describing the energy changes that occur in the filament when a current passes through it.

when a current passes through the filament, the energy changes from ~~electrical~~ mechanical energy to ~~mechanical~~ electrical energy.

High melting point because the torch is a parallel circuit

High melting point, small specific heat capacity and large resistance make incandesecent lamps work well in a circuit because it causes for there to ~~be increased current, therefore also increasing the function of the lamp~~ be a decreased current, slowing down the flow of electrons.

~~large increase in resistance, low current~~ increased current, when current increases, function also increases

~~current is the flow of electrons~~

resistance counter-acts against current

↑ resistance = ↓ current, ↓ function.

QUESTION THREE

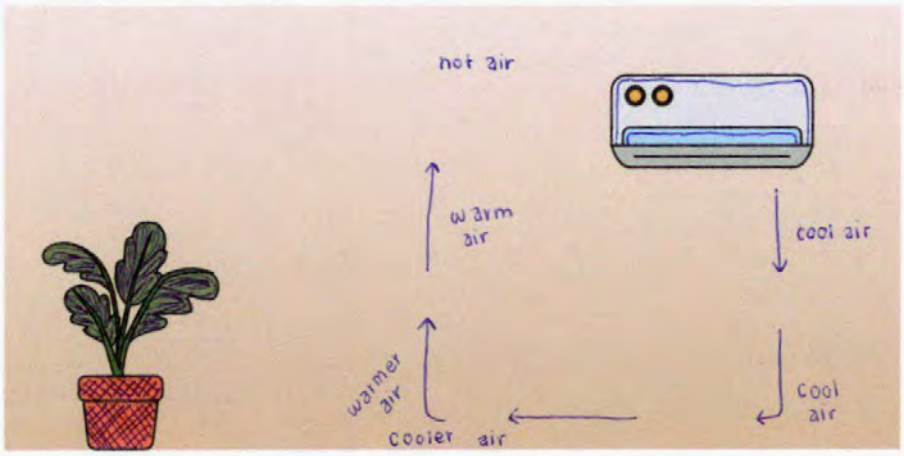
Pearl has had an air conditioning (AC) unit installed in her room. The AC unit uses electricity to cool down air and blow cooled-down air into her room. This way, Pearl's room is comfortably cool although it is hot outside.

AC units are typically mounted high up on a wall.

https://flitemechanical.com/mini-split/

(a) In the diagram below, draw labelled arrows to show the movement of warm air and cool air in the room.

Disregard effects of air being pushed out of the AC unit.



(b) The volume of space occupied by a given amount of air depends on the temperature of the air. This is the reason for the movement of warmer and cooler air around the room.

Explain, in terms of particle theory of matter, why a given amount of cooler air occupies a slightly smaller volume of space than the same mass of warmer air.

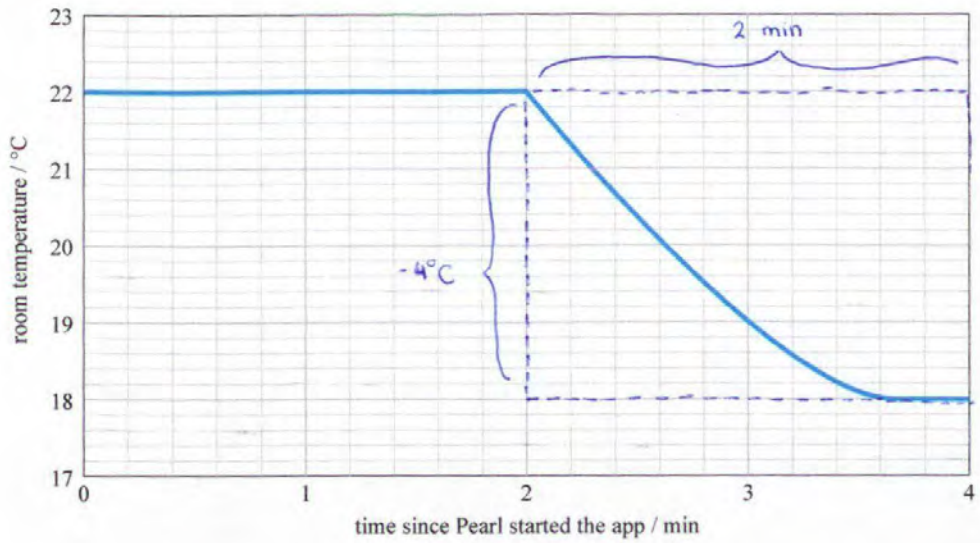
When air is heated, the air particles vibrate causing for them to expand, causing for volume of space of air particles to become less dense - air particles take up greater volume of space when less dense*

cooler particles = more dense, take up smaller volume of space.

Hot air rises - particles move around more freely in the room as they are less dense

* ~~able to move~~ greater ~~more~~ space between each particle when heated

(c) One summer morning, Pearl checks the room temperature on her phone. Two minutes after she starts the app, she sets the AC unit to 18 °C and switches it on. The temperature in her room drops as shown in the graph below.



Pearl's room contains 41.4 kg of dry air; the specific heat capacity of dry air is 718 J kg^{-1} $°C^{-1}$.

Using information from the graph above, **calculate the average power** of the AC unit in the two minutes after Pearl sets it to 18 °C.

Begin your answer by calculating the amount of thermal energy drawn from the air in Pearl's room.

E (thermal) = mcΔT. m = 41.4 kg, c = 718 Jkg^{-1}, ΔT = 4°C, E = 41.4 × 718 × 4

E = 118 900.8 J of ~~on~~ thermal energy drawn from air in Pearl's room

$\Delta E = P\Delta t$, E = 118900.8, Δt = 2, $P = \frac{\Delta E}{\Delta t}$, $P = \frac{118900.8}{2}$, P = 59 450.4 w

average power of AC unit in 2 minutes = 59 450.4 w

Question Three continues on the following page.

(d) At night, when it gets cold outside, Pearl closes the curtains on the window in her room. Pearl's curtains reach down to the floor and are close to the wall.

Explain why the layer of air between the curtain and the window reduces heat transfer by conduction through the glass of the window pane.

In your answer, you should:

- explain, in terms of particle theory of matter, how heat transfer by conduction works
- compare and contrast conduction through air and glass.

~~Curtains (fabric) is a good insulator~~

Seem as the curtains in Pearl's room are both, close to the wall and reach down to the floor, it means that the air particles are closer together - more dense

Heat transfer through conduction occurs ~~mainly in~~ more effectively in solids - done through when two materials ~~are touching~~ make contact with each other - as particles heat up, they vibrate and bump into each, causing for them to expand and heat transfer to occur.

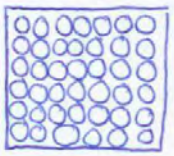
Conduction in air: particles further apart, able to move around more freely, slower to heat up, ~~more~~ because of space between each particle Slows down heat transfer between curtain and window ~~because~~

curtain and glass of window pane are not making physical contact with each other

Conduction through glass: partides are much closer together, generally ~~take~~ in smaller volume of space

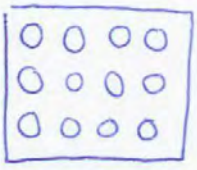
when heated, they vibrate, bump into the next particle, heat up all particles in the glass. thus making glass become warm

air becomes warm as particles expand when heated.



when heated: vibrate, expand

particles in glass



particles move more freely

particles in air

Merit

Subject: Physics, Earth and Space Science RAS

Standard: 92047

Total score: 16

Q	Grade score	Marker commentary
One	M6	• Candidate did not demonstrate a clear understanding of energy transfers in falling objects. • The candidate correctly found the difference between GPE and KE but did not then complete the final calculation to find the average force of friction ($F = W/d$). • The candidate used the correct formula but did not apply the 80% to 0.537 before completing the calculation. • The candidate showed a clear understanding of W=Fd and that when "net" forces are zero no work is done in (i) and (ii). The candidate also recognised that to climb the stairs forces must be unbalanced so work is done.
Two	A3	• Correct use of formula $R = V/I$. • Correct identification of the parallel circuit but no clear link to each pathway in the circuit having a PD of 4.5 V • Correct use of P=VI to calculate the power of a single bulb. Incorrect conversion of 2 hours into 7200 seconds resulting in a error to calculate total energy used by a single bulb. The candidate also recognised that they needed to account for the energy used by both bulbs. • The candidate did not demonstrate understanding of energy changes in a filament lightbulb and was not able to link the described features of a filament lightbulb with their benefits.
Three	E7	• Showed understanding of convection. • Describes density in terms of particle movement and spacing. • Correct calculation of energy used in four minutes but no conversion of time to seconds. • Good description of conduction and explaining how conduction is less effective in air compared with solids due to particle spacing and that the layer of air slows heat transfer between the curtain and the glass.

Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 1 Physics, Earth and Space Science RAS 2023

92047 Demonstrate understanding of energy in a physical system

EXEMPLAR

Excellence

TOTAL 22

You may find the following formulae useful.

$$E_k = \frac{1}{2}mv^2 \qquad \Delta E_p = mg\Delta h \qquad g = 10\ \text{N kg}^{-1} \qquad W = Fd$$

$$E(\text{thermal}) = mc\Delta T \qquad E(\text{thermal}) = mL$$

$$P = VI \qquad V = RI \qquad \Delta E = P\Delta t$$

QUESTION ONE

Jamie plays with his football while he waits for his bus. He throws the ball vertically up. The ball has a mass of 0.150 kg and reaches a height of 3.4 m. As it falls back down, its speed just before it hits the ground is 7.8 m s^{-1}.

(a) In the box below, write an equation to show the energy changes taking place when the ball falls back down from its highest point.

gravitational potential → kinetic + heat

(b) Calculate the size of the average force of friction between ball and air.

Begin your answer by showing that, on its way down from the highest point, 0.537 J of mechanical energy are changed into other forms of energy.

$E_p = mgh$

$0.150 \times 10 \times 3.4$

$E_p = 5.1\ J$

$5.1 - 4.563 = 0.537\ J$

$E_k = \frac{1}{2}mv^2$

$E_k = \frac{1}{2} \times 0.150 \times 7.8^2$

$E_k = 4.563\ J$

(c) While falling, 80% of the 0.537 J converted to other types of energy is absorbed by the ball. The specific heat capacity of the ball is 8200 J kg^{-1} $°C^{-1}$.

Calculate the rise in temperature of the ball as it falls.

$E = mc\Delta t$ $0.537 \times 0.8 = 0.4296$

Then

$0.4296 = 0.150 \times 8200 \times \Delta t$ $\frac{0.4296}{1230} = 0.00035\ °C$

$0.4296 = 1230 \times \Delta t$

(d) After some time, Jamie's bus did not arrive. Jamie shoulders his backpack and walks to the train station. On his way to the platform, he climbs a flight of stairs.

In terms of work and/or energy, explain why each of the following three statements given below is true.

No calculations are needed.

(i) (ii) (iii)

(i) No work is done on Jamie's backpack when Jamie is standing at the bus stop.

The backpack is not moving therefore W=fxd does not apply as the back pack is not moving a distance.

(ii) No work is done on Jamie's backpack when Jamie walks at constant speed on horizontal ground.

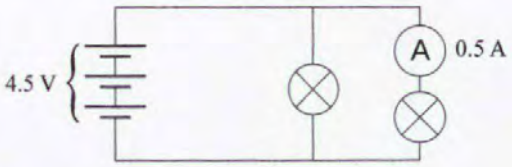
Although Jamie is moving no work is done on the backpack as it is not moving itself. No energy is transferred into the backpack.

(iii) Work is done on Jamie's backpack when Jamie climbs up a flight of stairs.

The backpack moves a vertical distance up the stairs, gaining gravitational potential energy so the equation W=fxd is applicable.

QUESTION TWO

Jake has a torch that uses three 1.5 V batteries in series. The torch has two lamps, each rated at 4.5 V, connected as shown in the circuit diagram below. The current through each lamp is 0.50 A.



(a) Calculate the resistance of each lamp.

V / I R

$V = IR$

$R = V/I$ $\quad 4.5/0.5 = 9\ \Omega$

(b) The batteries power both lamps simultaneously.

Explain why both lamps glow with their rated brightness if connected as shown above.

Begin your answer by identifying what type of connection the above diagram shows.

Both lamps glow with thier rated brightness as they are connected in parallell. This means that every ~~pathway~~ pathway has the full 4.5v from the three batteries. ~~the~~ Each bulb is rated at 4.5 v, therefore needing 4.5 v to glow at thier full brightness.

(c) Calculate the amount of electrical energy used by both lamps in two hours.

Begin your answer by calculating the power output of each lamp.

$P = VI$

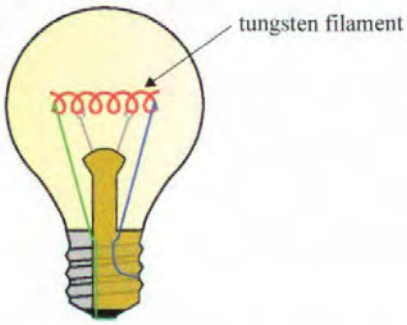
$4.5 \times 0.5 = 2.25\text{w}$ for each bulb

$\Delta E = P \Delta t$

$E = (2.25 + 2.25) \times 7200$s

$E = 32400$ J

(d) Jake's torch uses incandescent lamps. These lamps have a very thin tungsten wire called a 'filament'. When a current passes through such a filament, it heats up and glows.



Tungsten is a metal with a very high melting point and a relatively small specific heat capacity. The very small diameter of the filament means that the filament has a large resistance.

Explain why the high melting point, small specific heat capacity, and large resistance of the filament are important for the incandescent lamps to work well in a circuit.

Begin your answer by describing the energy changes that occur in the filament when a current passes through it.

When a current passes through the filament the electrical energy is converted to light and heat. The high melting point of tungsten means that it will not melt when heated as it needs a high temperature to melt. However, the small specific heat capacity means it requires a smaller amount of energy to heat it up one kg by 1°C. This means that it doesn't need a lot of energy (compared to some other metals) to heat up and glow, but will not melt. The filament has a large resistance as it has a small diameter. Resistance is inversely related to current so if $V = IR \uparrow$ the small diameter slows the flow of charges allowing for the transfer of energy from electrical to heat and light. The incandescent lamps work well in a circuit as they do not melt, require less energy to generate heat and light and have a large resistance

QUESTION THREE

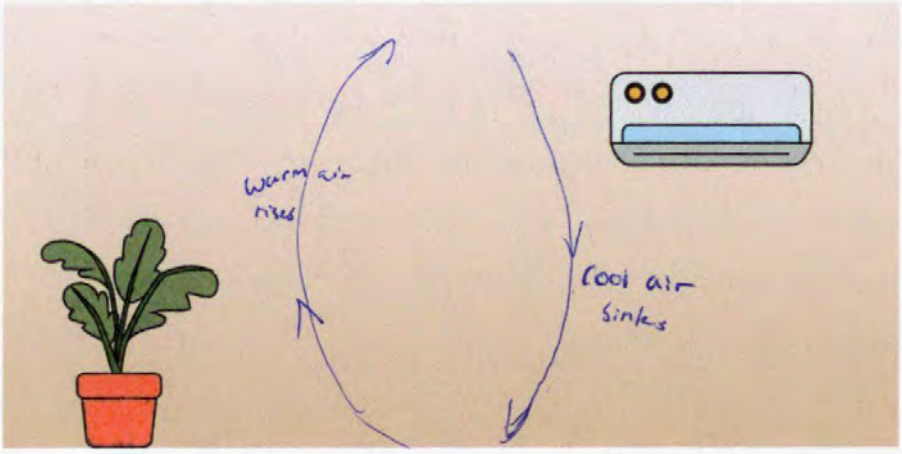
Pearl has had an air conditioning (AC) unit installed in her room. The AC unit uses electricity to cool down air and blow cooled-down air into her room. This way, Pearl's room is comfortably cool although it is hot outside.

AC units are typically mounted high up on a wall.

https://flitemechanical.com/mini-split/

(a) In the diagram below, draw labelled arrows to show the movement of warm air and cool air in the room.

Disregard effects of air being pushed out of the AC unit.

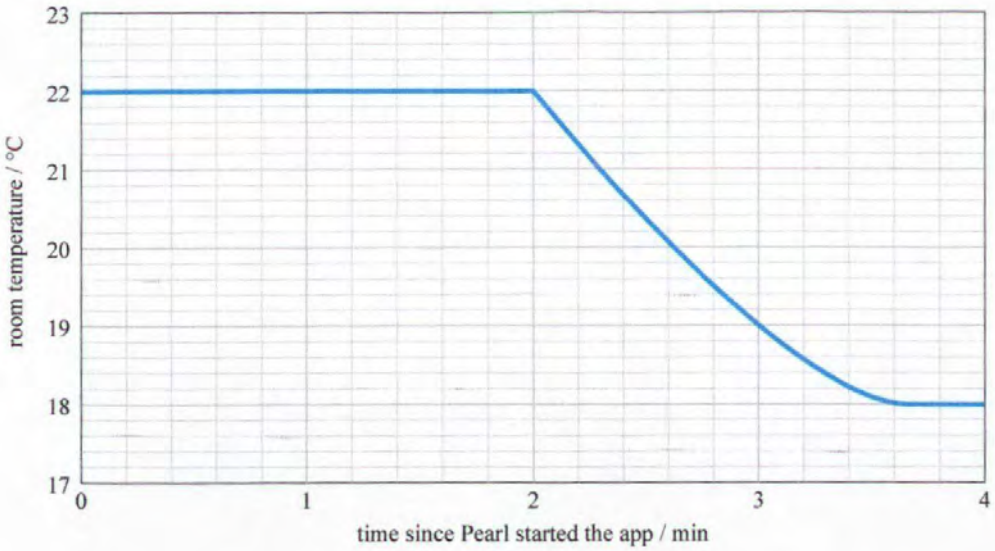


(b) The volume of space occupied by a given amount of air depends on the temperature of the air. This is the reason for the movement of warmer and cooler air around the room.

Explain, in terms of particle theory of matter, why a given amount of cooler air occupies a slightly smaller volume of space than the same mass of warmer air.

Cooler air occupies a smaller volume of space than warmer air because the particles have less energy. This means that they are moving around less and are closer together meaning that cooler air particles are more dense than warm air particles and thus take up less volume.

(c) One summer morning, Pearl checks the room temperature on her phone. Two minutes after she starts the app, she sets the AC unit to 18 °C and switches it on. The temperature in her room drops as shown in the graph below.



Pearl's room contains 41.4 kg of dry air; the specific heat capacity of dry air is 718 J kg^{-1} °C^{-1}.

Using information from the graph above, **calculate the average power** of the AC unit in the two minutes after Pearl sets it to 18 °C.

Begin your answer by calculating the amount of thermal energy drawn from the air in Pearl's room.

$Q = mc\Delta t$

$Q = 41.4 \times 718 \times 4$

$Q = 118900.8\ J$

$\Delta E = P\Delta t$

$118900.8 = P \times 240$

$\frac{118900.8}{240} = 495.42\ W$

Question Three continues on the following page.

(d) At night, when it gets cold outside, Pearl closes the curtains on the window in her room. Pearl's curtains reach down to the floor and are close to the wall.

Explain why the layer of air between the curtain and the window reduces heat transfer by conduction through the glass of the window pane.

In your answer, you should:

- explain, in terms of particle theory of matter, how heat transfer by conduction works
- compare and contrast conduction through air and glass.

Conduction transferrs heat through particles. As the particles close to the heat source heat up, they gain more energy so begin to vibrate more. The vibrating particles bumped into neighbouring particles and transfer on the heat. Thus & allowing heat transfer all through the object. Glass is a solid, so has a rigid structure and particles close together, this enables good conduction as the particles are close together, the bump into each other more frequently. Air, however, is a gas and is a poor conductor. This is because its particles are far apart and freely move, so the particles do not bump into each other as often as in a solid, like glass. The layer of air between the curtain and the glass reduces heat transfer from the room through the glass as it doesn't effectively transfer heat to the window pane, so not all the heat energy in the room is transferred through conduction to the window.

Excellence

Subject: Physics, Earth and Space Science RAS

Standard: 92047

Total score: 22

Q	Grade score	Marker commentary
One	M6	• Correct description of energy changes. • Correct calculations of GPE and KE to show the quantity of energy changed into other forms but no calculation to find the average force of friction. • Correct calculations to find the proportion of energy converted to heat and then the change in temperature of the ball. • Use of $W = Fd$ in (i) showing since $d = 0$ then ¼ = 0. Incorrect understanding of the physical system in (ii). Correct explanation in (iii) that changes in GPE mean work is being done.
Two	E8	• Correct use of $R = V/I$ • Correct identification of the parallel circuit and that each pathway in the circuit has a PD of 4.5 V. • Correct use of $P = VI$ to calculate the power of a single bulb and conversion of 2 hours into 7200 seconds. The candidate also recognised that they needed to account for the energy used by both bulbs. • Correct energy changes in the filament lightbulb and analysis of why the given features of a filament lightbulb are important to its function.
Three	E8	• Correctly describes convection. • Describes density in terms of cooler air having lower particle energy linked to less movement and reduced spacing compared to warmer air. • Correct calculation of energy used in four minutes but incorrect conversion of time to seconds. • Good description of conduction and analysis of how conduction is less effective in air compared with solids due to comparative particle spacing and that the layer of air slows heat transfer between the curtain and the glass.