

Model Solutions for Round 1

1. 5 solar panels left in the sun for 5 days collectively generate 5 units of electricity. Under the same conditions, how many units of electricity would be generated by 1 solar panel in 10 days?

A: 0.4 B: 2 C: 2.5

Correct Answer: B

5 solar panels for 5 days will generate the same electricity as 1 solar panel for $5 \times 5 = 25$ days

So 1 solar panel generates 5 units in 25 days. In 1 day it generates $5/25 = 0.2$ units so in 10 days it will generate $10 \times 0.2 = 2$ units.

2. A lake in the shape of a rectangular prism has dimensions 10 metres by 20 metres by 1.5 metres. If the lake has 175 cubic metres of water in it, express this as a fraction of the total volume the lake can contain.

A: $1/2$ B: $4/7$ C: $7/12$

Correct Answer: C

The total volume of the Lake is $10 \times 20 \times 1.5 = 300$ cubic metres.

We have $175/300$ as a fraction, to simplify this we notice 175 & 300 are divisible by 5, $175/5 = 35$, $300/5 = 60$, so we have $35/60$.

Again, we see these are both divisible by 5, $35/5 = 7$, $60/5 = 12$, giving us $7/12$.

3. Sarah calculates it takes an hour and costs 30p to heat her house fully when cold, and 15p per hour to maintain that temperature afterwards. If she has spent £1.20 on heating today, and her house was cold at the start of the day, how many hours has Sarah's heating been on?

A: 5 hours B: 6 hours C: 7 hours

Correct Answer: C

She has spent £1.20 on heating her house, therefore she must have turned the heating on and spent 30p, so she has spent 90p maintaining the heat to this level. $90/15 = 6$, therefore we have 7 hours total.

Students may choose to use linear equations and solve $120 = 15x + 30$, but they do then have to bear in mind that the 30 pence contributes an hour as well.

4. Rodrigo has a rain collector which has a surface area of 100,000 square centimetres. How much water, in litres, will he collect in a thunderstorm where 4cm of rain falls.

You may use the fact that 1000cm^3 of liquid is one litre.

A: 40 litres B: 400 litres C: 4000 litres

Correct Answer: B

4cm of rain over an area of 100,000 square centimetres is $4 \times 100,000 = 400,000$ cubic centimetres

This is 400 litres using the hint given.

5. In the months of July, August and September 2019, 20% of energy in the UK was generated by wind power, 12% by biomass and 6% by solar power. Express this as a ratio in its simplest terms.

A: 1:2:3 B: 3:2:1 C: 10:6:3

Correct Answer: C

20, 12, and 6 have a common factor of 2, the original ratio would be 20:12:6, so dividing all components by 2 gives 10:6:3

6. Between the years 1975-2017, the average volume of water flowing in Australia's rivers was 134 billion litres per annum. In the final 6 years of this period an average of 46 billion litres has been flowing per annum. On average, how much water was flowing each year between 1975 and 2011 to 2 significant figures?

A: 150 billion litres B: 134 billion litres C: 90 billion litres

Correct Answer: A

We have to set up an equation for this based on how we typically calculate an average, we get

$$(46 \times 6 + 36 \times x) / 42 = 134$$

$$46 \times 6 + 36 \times x = 134 \times 42 = 5628$$

$$36 \times x = 5628 - 276 = 5352$$

$$x = 5352 / 36 = 148.66... \quad x = 150 \text{ billion litres to 2sf}$$

7. In 2019, Country A emitted 200 million tonnes of carbon dioxide, while country B emitted 150 million tonnes. Country A will cut its emissions by 7 million tonnes each year while country B will increase its emissions by 5 million tonnes each year.

In which year will the emissions of each country be closest to each other?

A: 2021 B: 2023 C: 2025

Correct Answer: B

For country A we have the expression $200 - 7x$

For country B we have the expression $150 + 5x$ where x represents the number of years

since 2019. We are looking for when these are closest, so we set the expressions equal to each other

$$200 - 7x = 150 + 5x$$

$$200 - 150 = 5x + 7x$$

$$50 = 12x$$

$$x = 50/12$$

So x is slightly larger than 4, thus they will be the closest 4 years after 2019, $2019 + 4 = 2023$

8. It costs £600 to keep Amelia's house warm through winter, if she were to purchase a new type of insulation for £300 it would then only cost her £500 to keep her house warm during winter. Assuming Amelia only uses her heating during winter, after how many years will the new insulation have saved her money?

Source: <https://www.weflip.com/articles/average-gas-electric-bill-uk/>

A: 2 years B: 3 years C: Never

Correct answer: B

With no insulation, the cost of heating is $600x$, while with insulation the total cost will be $300 + 500x$, with the extra 300 coming from the initial cost of purchasing the insulation. We solve this by doing

$$600x = 300 + 500x$$

$$600x - 500x = 300 \quad 100x = 300$$

$$x = 3$$

9. A cylindrical iceberg has a radius of 20m. A while later, it was discovered that the iceberg had lost 36% of its surface area (on the top face) due to melting and had remained cylindrical. What is the new radius of the iceberg?

A: 12.8m B: 14m C: 16m

Correct Answer: C

Area of top face initial = $400 \cdot \pi$

Area of top face final = $(1 - 0.36) \cdot 400\pi = 0.64 \cdot 400\pi = 0.8 \cdot 0.8 \cdot 400\pi = 0.8 \cdot 320\pi = 256\pi$
 $16^2 = 256$, this can be seen as 1024 is commonly known as 2^{10} , thus 2^8 is 256. $2^8 = (2^4)^2 = 16^2$ giving our answer as 16 m.

10. The roof of a house can be modelled as a triangular prism, the triangular face is isosceles with width 6m and perpendicular height of 4m and the roof is 10m long. George has a supply of solar panels which have dimensions 2 metres by 1 metre, what is the maximum number of solar panels George can install on his roof? Assume George lives in a terraced house such that he cannot install them on the triangular faces.

A: 50 B: 25 C: 40

Correct Answer: A

We start by calculating the lengths of the other two sides. The width is 6m and we know the height is 4m, so we break the isosceles triangle into two right angle triangles with one side of length 3m, another of length 4m and the hypotenuse is unknown. This is a common Pythagorean triple (3,4,5). You can also use the fact that $3^2 + 4^2 = 25$ if the students are not aware of this.

So now we have two rectangular faces each of size 5m * 10m = 50 square metres. Notice that the solar panels will tessellate on the surface of the roof due to its dimensions, so we can guarantee that the whole number is correct. This means we can fit precisely $50 / 2 = 25$ solar panels on each of the rectangular faces. This gives 50 in total.

Model Solutions for Round 2

Calculator Round:

6. It takes 14980 litres of water to produce one kilogram of beef, and 899 litres to produce one kilogram of corn. If the water used to produce one kilogram of beef was instead used to make corn, how many kilograms of corn could be produced to 2dp?

A: 0.06 kg B: 16.66 kg C: 18.53 kg

Correct Answer: B

This can be found with the calculation $14980 / 899 = 16.6629...$ This is 16.66 kg to 2dp.

2. 2.1 billion single-use carrier bags were sold by large retailers in the UK in 2017 for 5p each. If the UK population was 65.7 million that year, how much did the average Brit spend on single-use carrier bags to the nearest penny?

A: £0.15 B: £1.36 C: £1.60

Correct Answer: C

First we can find how many bags the average Brit bought. This can be found by computing $2.1 \text{ billion} / 65.7 \text{ million} = 31.963...$
 $31.963... \times 5$ gives 159.8... pence, which is £1.60 to the nearest penny.

3. In the USA, from January 1st to September 8th, 4.2 million acres of land were burnt in wildfires in 2019, compared to 4.7 million acres in 2020 over the same period. Calculate, to the nearest percent, the percentage increase in land burnt from 2019 to 2020.

A: 11% B: 12% C: 111%

Correct Answer: B

Percentage change can be found by first finding the difference between the old figure and the new figure, then dividing that by the old figure and multiplying by 100:
 $100 \times (4.7 \text{ million} - 4.2 \text{ million}) / (4.2 \text{ million}) = 11.904\dots$

This is 12% to the nearest percentage point.

4. A circular solar panel has a diameter of 150mm, what is the area of this solar panel in millimetres squared to the nearest whole number?

A: 22500 B: 17671 C: 70686

Correct Answer: B

Diameter is twice the radius, so we can find the radius by $150/2 = 75$.
Then using the formula for the area of a circle πr^2 , we find the area as $\pi \times 75^2 = 17671.45\dots$

This is 17671 square mm to the nearest whole number.

5. In the morning, Mr Cage drives his car to work. It is a 5 minute drive and he travels at an average speed of 24 miles per hour. That evening, he decides to be eco-friendly and he walks home – this takes him 40 minutes at an average speed of 3 miles per hour.

Find Mr Cage's average speed over his morning and evening commute to 3 significant figures.

A: 4.33 mph B: 13.5 mph C: 5.33 mph

Correct Answer: C

We need to take an average taking into account he spends different amounts of time at each speed.

Therefore we can calculate this by first finding:

$$(5 \times 24) + (40 \times 3) = 240$$

Then finding the average of this over the $40 + 5 = 45$ minutes. $240 / 45 = 5.3333\dots$, which is 5.33 mph to 3 significant figures.

6. Below is a table consisting of the top 5 countries which emitted the most CO₂ in the year 2017, where the units are mega tonnes of CO₂ and figures are given to 1 decimal place. What was the mean mass of CO₂ produced by the top 3 countries (in 2017) in mega tonnes to 1 decimal place?

	1990	2005	2017
China	2397.0	6263.0	10877.2
USA	5085.9	5971.6	5107.4
India	606.0	1210.8	2454.8
Russia	2379.0	1734.0	1764.9
Japan	1149.4	1276.9	1320.8

Source <https://ec.europa.eu/jrc/en/publication/fossil-co2-emissions-all-world-countries-2018-report>.

A: 4305.0 mega tonnes B: 6146.5 mega tonnes C: 6146.3 mega tonnes

Correct Answer: B

The emissions of the top 3 countries in 2017 were 10877.2, 5107.4, and 2454.8. The average can be found by summing these figures to get 18439.2. Averaging by dividing by 3 gives 6146.46666... This is 6146.5 mega tonnes to 1 decimal place.

7.

	1990	2005	2017
China	2397.0	6263.0	10877.2
USA	5085.9	5971.6	5107.4
India	606.0	1210.8	2454.8
Russia	2379.0	1734.0	1764.9
Japan	1149.4	1276.9	1320.8

Using the table above and considering all 5 countries given, find the ratio N/P where N is the mean CO_2 produced in 2005, and P is the mean CO_2 produced in 1990, give your answer correct to 3 significant figures.

Source: <https://ec.europa.eu/jrc/en/publication/fossil-co2-emissions-all-world-countries-2018-report>.

A: 1.42 B: 1.63 C: 1.39

Correct Answer: A

Using the same method as in question 6 but now dividing by 5 to account for 5 pieces of data, N can be calculated as 3291.26 and P can be calculated as 2323.46.

The final answer is found by the calculation $3291.26 / 2323.46 = 1.4165...$ which is 1.42 to 3 significant figures.

8. A bathtub in the shape of a rectangular prism (1.5m long x 50cm wide x 1m high) is half full of water. A block of ice (1m x 20cm x 20cm) is placed into the bath. Considering water expands by about 9% when frozen, find, to 3dp, the new height of the water in the bath when all the ice has melted.

A: 0.549m B: 0.558m C: 0.562m

Correct answer: A

The volume of the block of ice can be calculated with $1 \times 0.2 \times 0.2 = 0.04$ cubic metres - the 20cm has been converted into metres here.

Water expands by about 9% when frozen, so to find the volume of water once the ice has melted, we calculate $0.04 / 1.09 = 0.036697...$

Finally we must find how high this new water is when it has spread to fill the bathtub. This can be achieved by dividing the volume of water by the surface area of the bathtub: $0.036697 / (1.5 \times 0.5) = 0.048929...$

We are asked to find the final height of the water. As we are told the bathtub is half full, the height of water to begin with must be 0.5m. The final answer is found by the calculation $0.5 + 0.048929... = 0.54892...$

This is 0.549m to 3 decimal places.

9. A wind turbine goes through 20 revolutions per minute, given that the blades are 36.5 metres long, how fast is the tip of the blade rotating in metres per second? Give your answer to 1 decimal place.

A: 76.4 B: 38.2 C: 52.4

Correct Answer: A

We first need to find the circumference of the circle traced out by the tip of each blade. Using circumference = $2\pi r$, we get a circumference of 73π metres.

We are told the blade rotates through 20 revolutions per minute, so the tip of the blade moves through $20 \times 73\pi = 1460\pi$ metres per minute.

**We finally need to convert this into metres per second, achieved by dividing by 60.
 $1460\pi / 60 = 76.4454\dots$**

This is 76.4 metres per second to 1 dp.

10. The Atla wind energy centre generates 1500 million joules per second on 3200 acres (13 square kilometres) of land. The Bhadla Solar park generates 2245 million Joules of energy per second on 57 square kilometres of land. Calculate the difference in energy generated per second per square kilometre to 2 significant figures.

A: 76 B: 80 C: 18

Correct Answer: A

We first need to calculate the energy generation per second per square kilometre of each site.

For Atla, this is found by the calculation $1500 \text{ million} / 13 = 115.38\dots \text{ million}$

For Bhadla, we have $2245 \text{ million} / 57 = 39.385\dots \text{ million}$.

**The difference is found by subtracting the smaller figure from the larger figure:
 $115.38\dots \text{ million} - 39.385\dots \text{ million} = 75.9986\dots \text{ million}$, which is 76 million joules per second per square kilometre to 2 significant figures.**