**Activity 2: Worked answers**

# Practice question 1

**Step 1: Define the variables.**

Remember, the base of this house is a rectangle.

* Let be the width of the warehouse (in metres).
* The length is twice the width, so the length is (in metres).
* Let be the height of the warehouse (in metres).

The volume, , of the warehouse is 2400 m3 so:

Solve for :

**Step 2: Set up the heat loss equations.**

**Heat loss through the walls**

There are two walls of size , and two walls of size .

The total wall area, , in terms of is:

Substitute into the equation:

The heat loss through the walls is proportional to the wall area.

Using the heat loss equation for the wall:

**Heat loss through the roof**

The area of the roof (length × width) is

We are told that twice as much heat per square metre is lost through the roof as through the walls. So know that

Therefore, the heat loss through the roof is:

**Step 3: Combine the heat loss equations to calculate total heat loss.**

Take out the common factor :

**Step 4: Use differentiation to find the point at which heat loss is a minimum.**

To minimise the heat loss, we need to differentiate the total heat loss function with respect to and set the derivative equal to 0.

We can ignore the constant since it does not affect the minimisation.   
Rewrite the function as

Then rewrite this with a negative power and differentiate:

**Step 5: Set the derivative equal to 0 to find the critical points, and solve the equation.**

So:

Rearrange the equation to make the terms positive and solve:

**Step 6: Find the length and height.**

The length is twice the width, so length =

Use the formula for to find the height:

**Step 7: Verify it’s a minimum.**

To verify that this is a minimum, check the second derivative of .

Substitute in

Since 24 > 0, the second derivative is positive, confirming that gives a minimum.

**Final answer**

The dimensions of the warehouse that minimise heat loss are approximately:

* Width = 9.65 m
* Length = 19.3 m
* Height = 12.89 m

# Practice question 2 – fully worked example

**Step 1: Define the variables.**

* Let be the width of the storage unit in metres.
* The length is three times the width, so the length is (in metres).
* Let be the height of the storage unit in metres.

The volume of the storage unit is 3600 m3 so:

Solve for :

**Step 2: Set up the heat loss equations.**

**Heat loss through the walls**

There are two walls of size , and two walls of size .

The total wall area is:

Substitute into the equation:

The heat loss through the walls is proportional to the wall area. Use the heat loss equation for the wall:

**Heat loss through the roof**

The area of the roof

We know that 50% more heat per square metre is lost through the roof as through the walls. This means we know that

Use the heat loss equation for the roof:

**Step 3: Combine the heat loss equations to calculate total heat loss.**

The total heat loss is the sum of the heat loss through the walls and the roof:

Take out the common factor :

**Step 4: Use differentiation to find the point at which heat loss is at a minimum.**

To minimise the heat loss, we need to differentiate the total heat loss function with respect to and set the derivative equal to 0.

We can ignore the constant since it does not affect the minimisation.

Rewrite the function as:

Then rewrite this with a negative power and differentiate:

**Step 5: Set the derivative equal to zero to find the critical points, and solve the equation.**

So:

Rearrange the equation to make the terms positive and solve:

**Step 6: Find the length and height.**

Now that we know the width, we can find the length and height.

The length is three times the width, so:

Length

The height is given by:

**Step 7: Verify it’s a minimum.**

To verify that this is a minimum, check the second derivative of .

Substitute in

Since 27.5 > 0, the second derivative is positive, confirming that gives a minimum.

**Final answer**

The dimensions of the storage unit that minimise heat loss are approximately:

* Width = 10.2 m
* Length = 30.6 m
* Height = 11.5 m