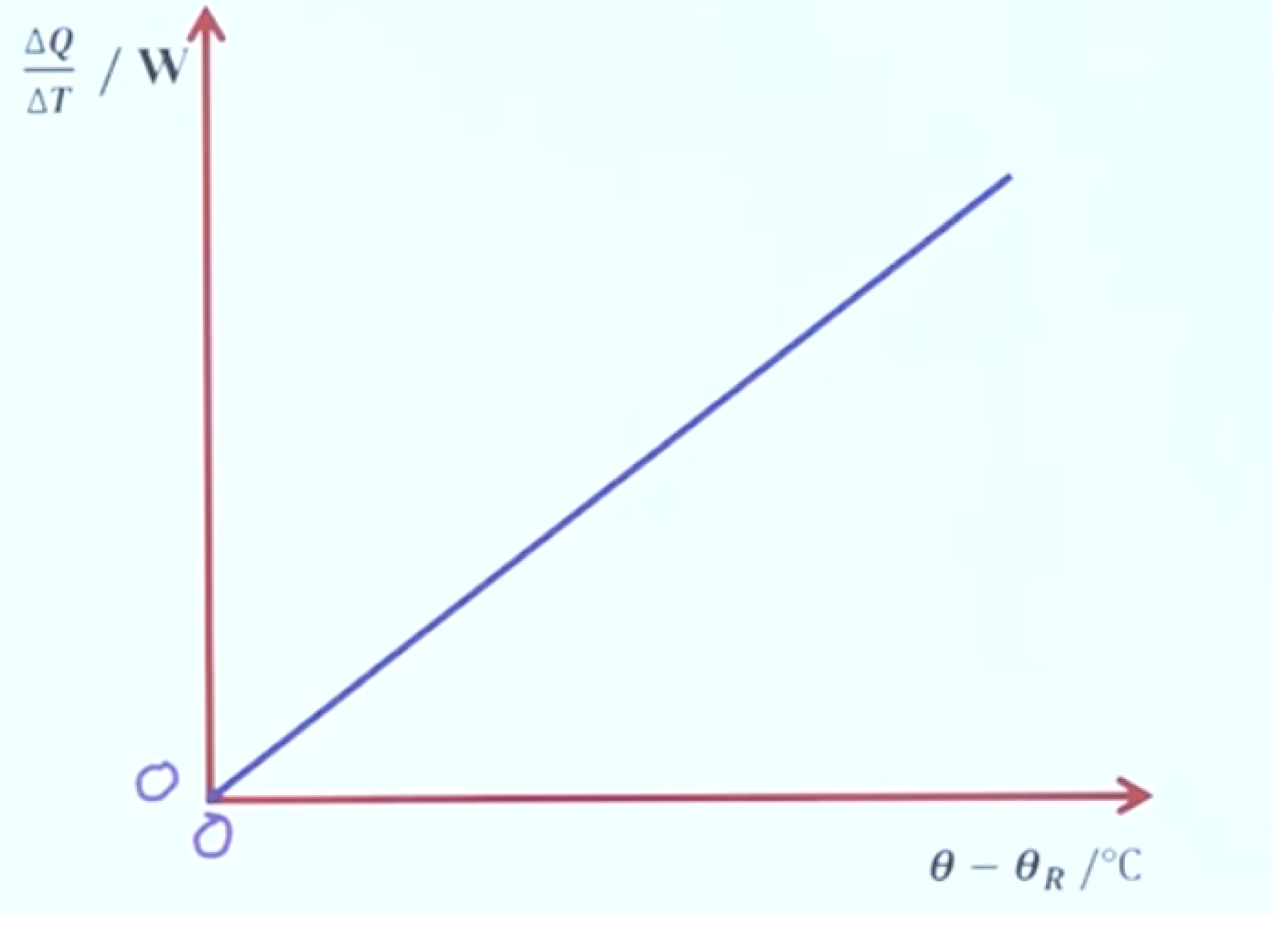
- Newton's Law of Cooling

> The cooling rate is proportional to the excess temperature.

$$\frac{d\theta}{dt} \propto (\theta_S - \theta_R)$$

$$\frac{d\theta}{dt} = \frac{KA}{mS}(\theta_S - \theta_R)$$

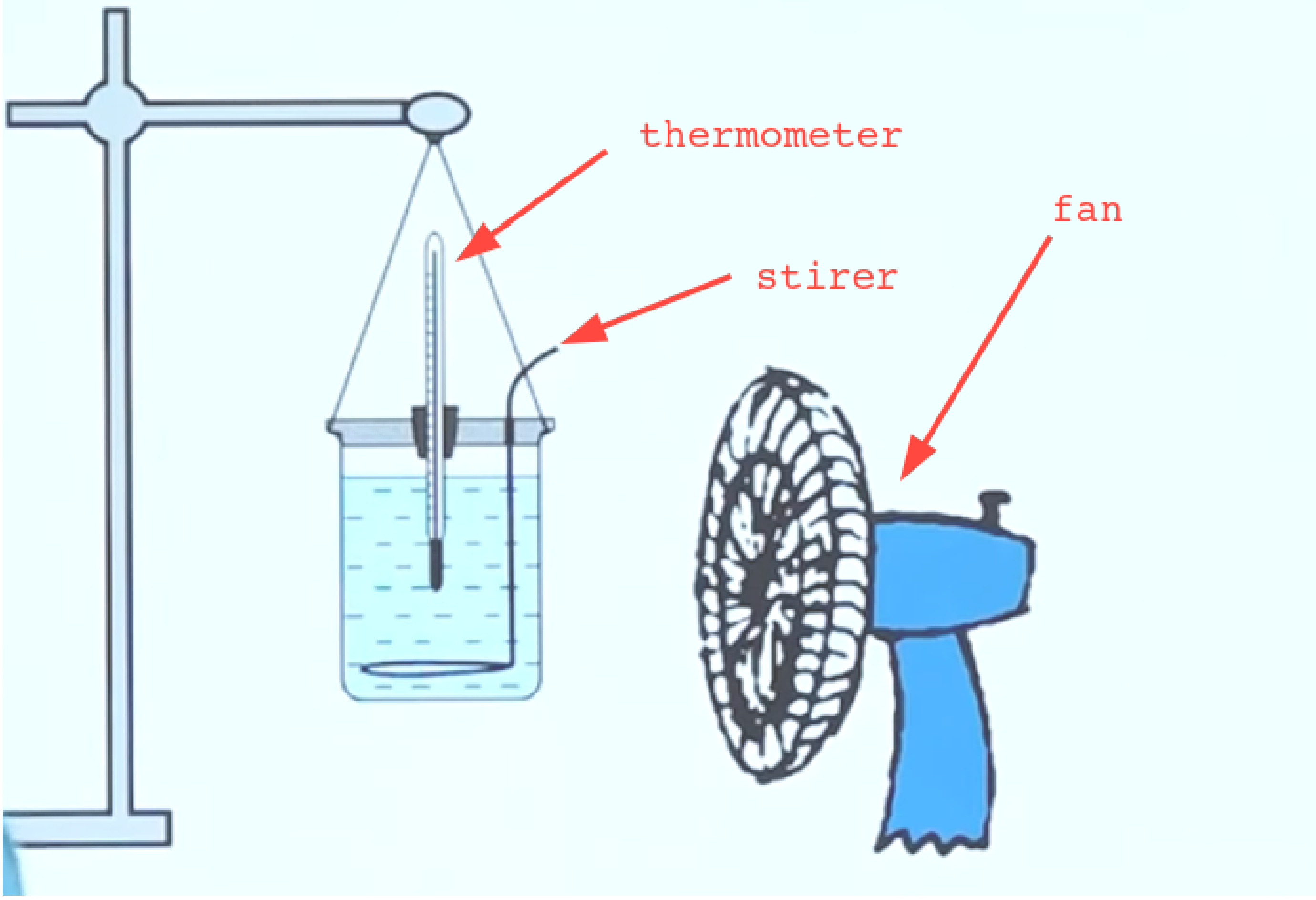
> To prove this we just need to take a graph for this $\frac{d\theta}{dt} \propto (\theta_S - \theta_R)$ which means a $y = mx$ type for $\frac{d\theta}{dt}$ and $\theta_S - \theta_R$



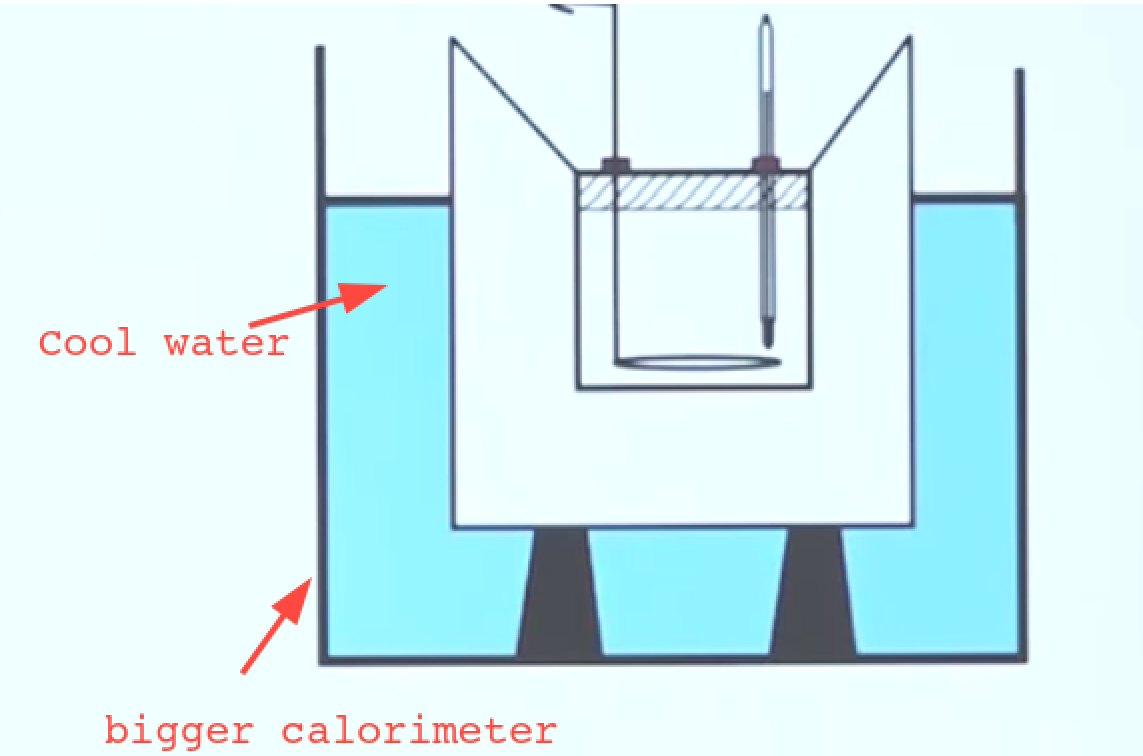
- Setup

There are 2 methods to do this,
1. With forced convection
2. With Natural convection

> For force convection we use an electric fan



> For natural convection, we keep the calorimeter inside a bigger calorimeter filled with cool water



This is to make sure the inside of the small calorimeter has the same environment conditions throughout the experiment.

- Setps

1. Then, We heat the calorimeter with water(the liquid) to around 80 Celsius and let it cool down.
2. Then take the temperature of the water inside in **equal time intervals**.

$$
\begin{aligned}
After\ 30\ seconds &\rightarrow 70^oC \\
After\ 40\ seconds &\rightarrow 60^oC \\
After\ 50\ seconds &\rightarrow 55^oC
\end{aligned}
$$

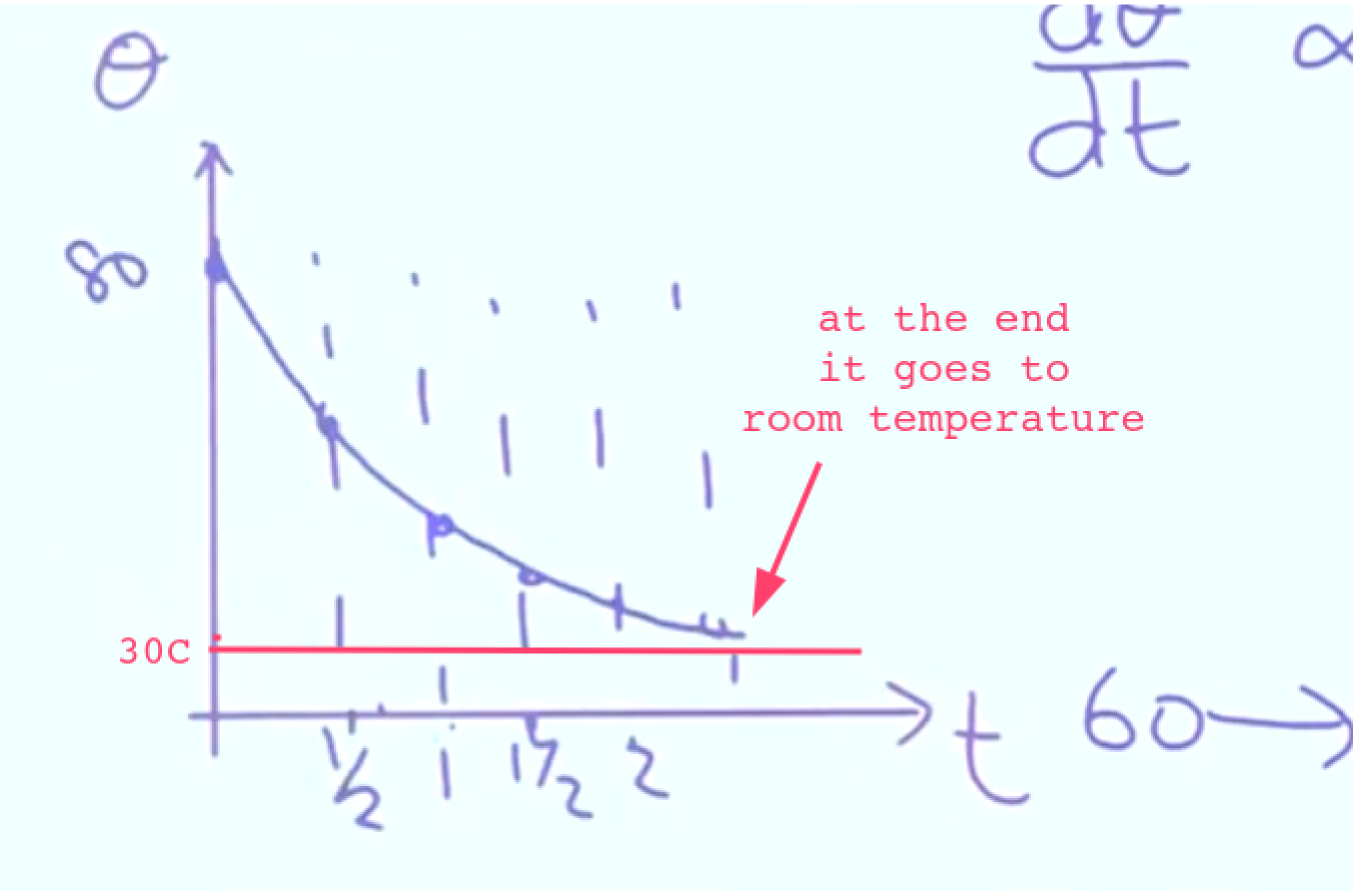
3. Stop the experiment once the temperature is around 40C and let it come to room temperature. Then measure, the room temperature θ_R using the same water inside the calorimeter (say 30 Celsius)
4. Get the excess temperature according to these readings.

$$\theta_R = 30^oC$$

$$\theta_E = (\theta_S - \theta_R)$$

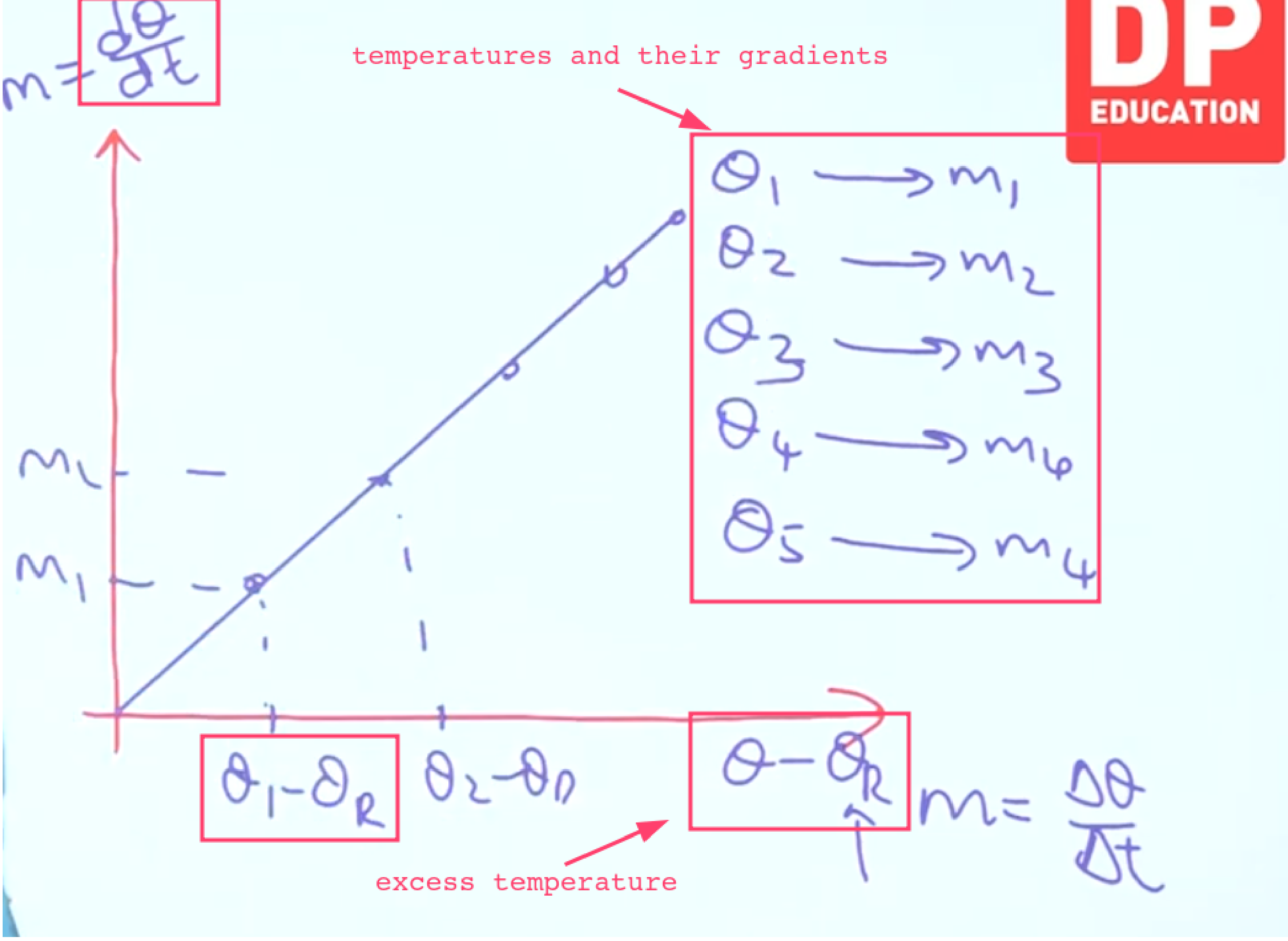
$$
\begin{aligned}
After\ 30\ seconds \rightarrow \theta_E &= (70-30) = 40 \\
After\ 40\ seconds \rightarrow \theta_E &= (60-30) = 30 \\
After\ 50\ seconds \rightarrow \theta_E &= (55-30) = 25
\end{aligned}
$$

Then plot the graph.



And then to prove this, select 3,4 points on the graph and find the respective temperatures and their gradients.
Here the gradient is actually the cooling rate $\frac{d\theta}{dt}$.

> Then we draw another graph for the **gradient (cooling rate)** $\frac{d\theta}{dt}$ and **excess temperature** relevant to those temperatures we chose $(\theta - \theta_R)$



> The expected graph is $y = mx$. If so then the newton's law is verified.

Important points

- What are the main readings you are getting in this experiment?

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Room temperature
Temperature of the water in constant intervals
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- Why can't we use a glass beaker for this experiment?

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Since glass is a poor thermal conductor the surface and the inside liquid temperature will be different. Therefore we need to use a good thermal conducting material like copper for this.
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- Why do we have to keep stiring during the entire time?

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To make sure the temperature is uniform through out the water and the surface of the calorimeter.
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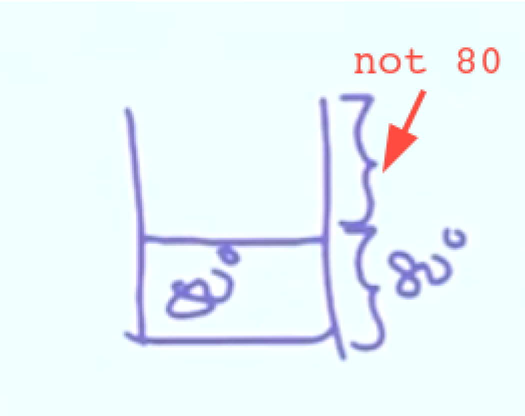
- Why do we have to keep the water inside the (small) calorimeter up to 1cm from the brim?

If we have the water up to half of the calorimeter, we can't make sure that the entire calorimeter has the same surface temperature because the top part is not in contact with water.



Also we can't full it upto the very top beacuse when we are stiring it water might get spilled.

- Why do we stop the experiment when the thermometer temperature is around 40 Celsius?

Because 40 is close to room temperature, and therefore the rate of loosing reat is very slow. It takes very long time to loose the temperature.

- Why is using the forced convection method leads to more accurate readings?

When it comes to very high temperatures like 200C the excess temperature is more than 100C, therefore with natural convection measuring this big excess temeperatures could be lead to errors as the environment could change due to high heat lost.

- If we were given a mirror to find the gradients of the temperature points in the first graph how can you do it?

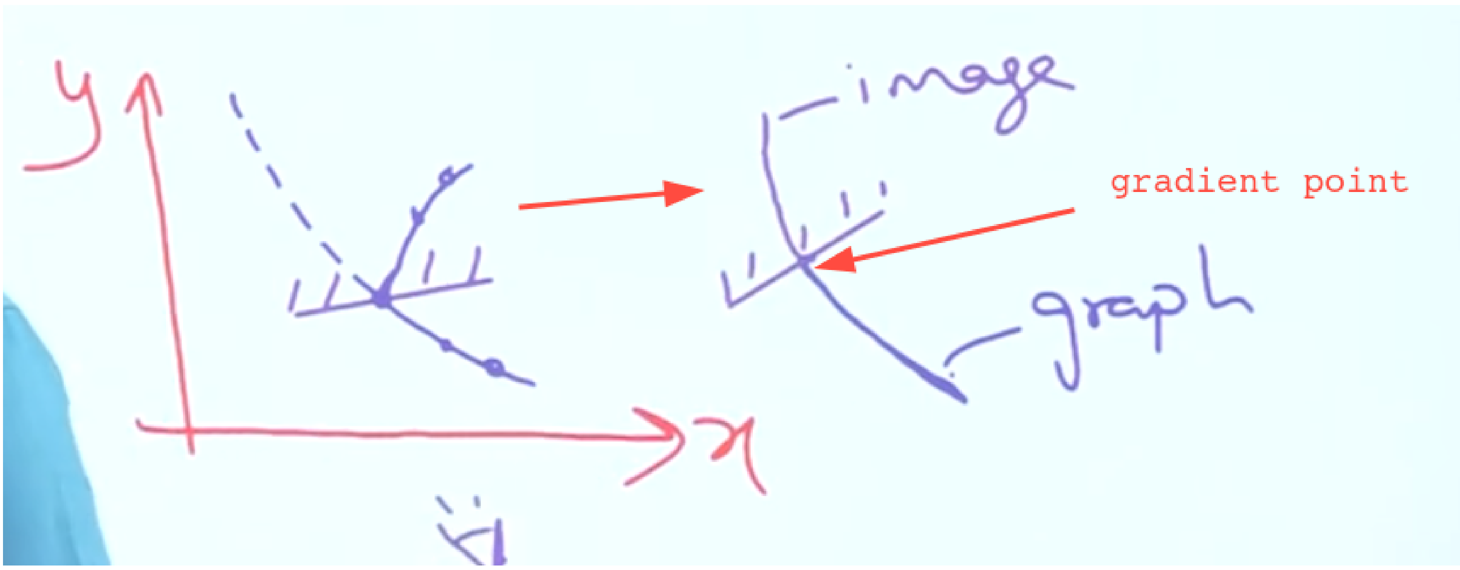
Method to find the gradient

Place the mirror on the curve at the point where we want the tangent such that its reflecting surface is perpendicular to the plane of the paper and is facing you.

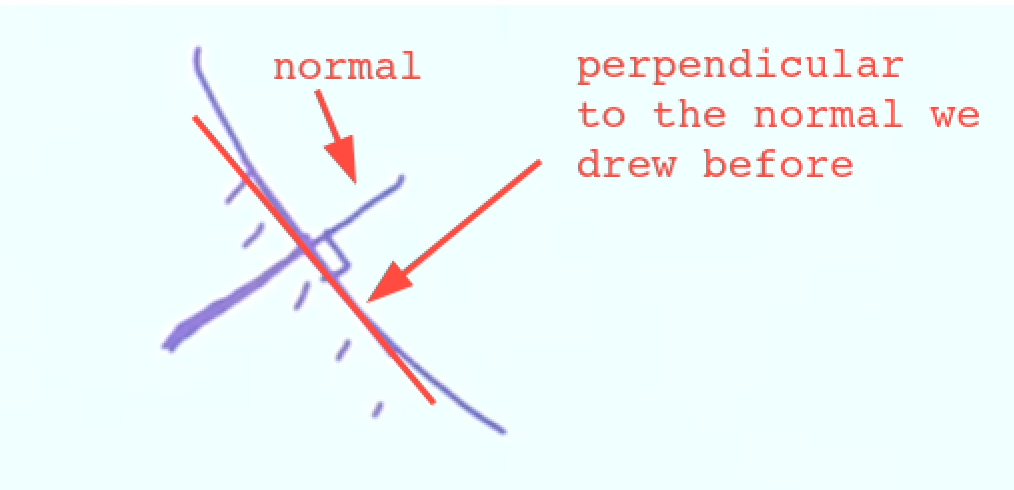
Now look at the curve just in front of the mirror and its reflection and think of this curve and its reflection as one continuous line.

You would see that this continuous line has a sharp point at the point where the curve meets its image on the mirror.

Now move the mirror such that this sharp point is eliminated i.e. the curve moves on to its image smoothly. This happens when the curve is perpendicular to the mirror at the point where it meets the mirror. Since the curve is perpendicular to the mirror, its image is also perpendicular to the mirror.



This is normal to the curve



> This is the tangent