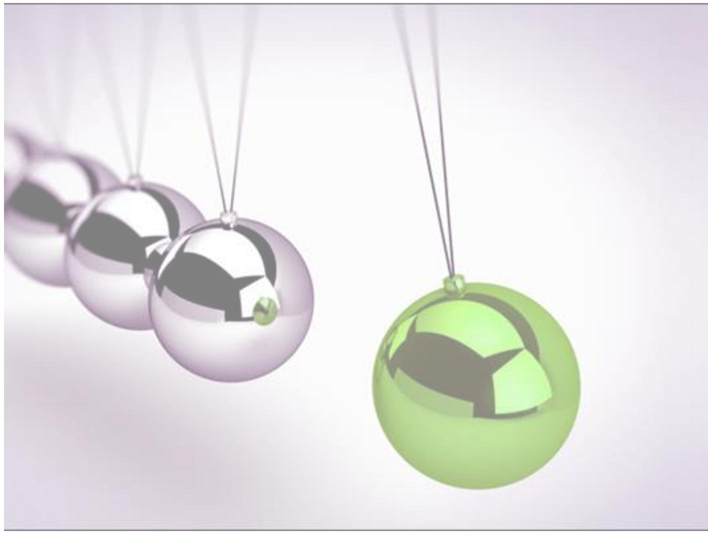
Mechanics & Materials

2015 AQA A Level Physics

Energy, Efficiency and Power



Kinetic energy

Any object that moves will have kinetic energy.

The amount of kinetic energy an object has can be found using the formula:

Kinetic energy = ½ x mass x velocity squared

in J *in kg* *in m/s*

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

Kinetic Energy questions

1) Zoe drives her car at a speed of $20ms^{-1}$. If the combined mass of her and the car is 1200kg what is her kinetic energy?

2) Ben rides his bike at a speed of $10ms^{-1}$. If the combined mass of Ben and his bike is 80kg what is his kinetic energy?

3) Will is running and has a kinetic energy of 750J. If his mass is 60kg how fast is he running?

4) Connor is walking to town. If he has a kinetic energy of 150J and he's walking at a pace of $2ms^{-1}$ what is his mass?

Gravitational Potential Energy

To work out how much gravitational potential energy (GPE) an object gains when it is lifted up we would use the simple equation…

$$\Delta E_{grav} \quad = \quad \text{Weight} \quad \times \quad \text{Change in height}$$

(Joules) *(newtons)* *(metres)*

(Remember - W=mg)

Some example questions…

How much gravitational potential energy have the following objects gained?:

1. A brick that weighs 15N lifted to the top of a house (9m),
2. A 1,000kg car lifted by a ramp up to a height of 2.5m,
3. A 65kg person lifted up 50cm by a friend.

How much GPE have the following objects lost?:

1. A 2.5N football dropping out of the air after being kicked up 30m,
2. A 0.7N egg falling 10m out of a bird nest,
3. A 1,000kg car falling off its 260cm ramp.

Energy changes for a skydiver

Meet our skydiver:

If the skydiver has reached terminal velocity explain what happened to his…

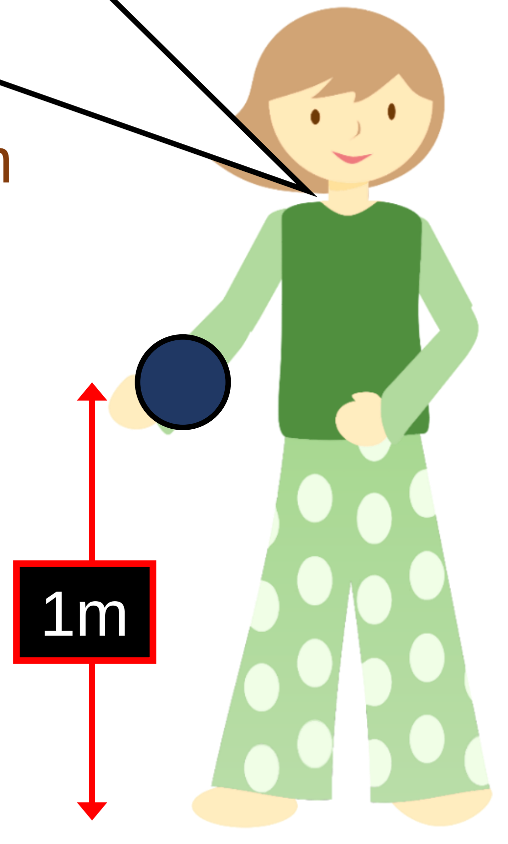
1) Kinetic energy
2) Gravitational potential energy

…during his skydive.

Using conservation of energy when dropping objects

If I drop this ball from 1m, how fast will it be going when it hits the floor?

HINT: Use GPE at top = Kinetic energy at bottom



Using conservation of energy when dropping objects

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Use GPE at top = Kinetic energy at bottom

$$mgh = \tfrac{1}{2}mv^2$$

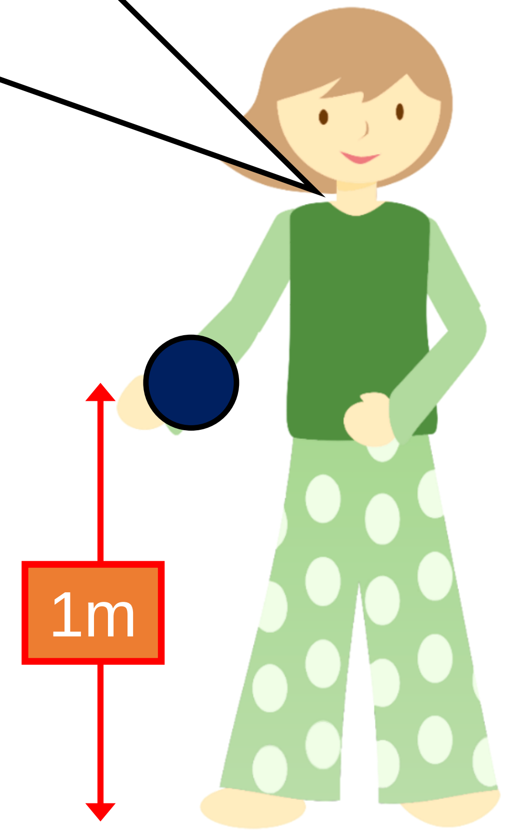
$$gh = \tfrac{1}{2}v^2$$

$$h = \frac{v^2}{2g}$$

$$v^2 = 2 \times 9.81 \times 1$$

$$v^2 = 19.62$$

$$v = 4.43\text{m/s}$$



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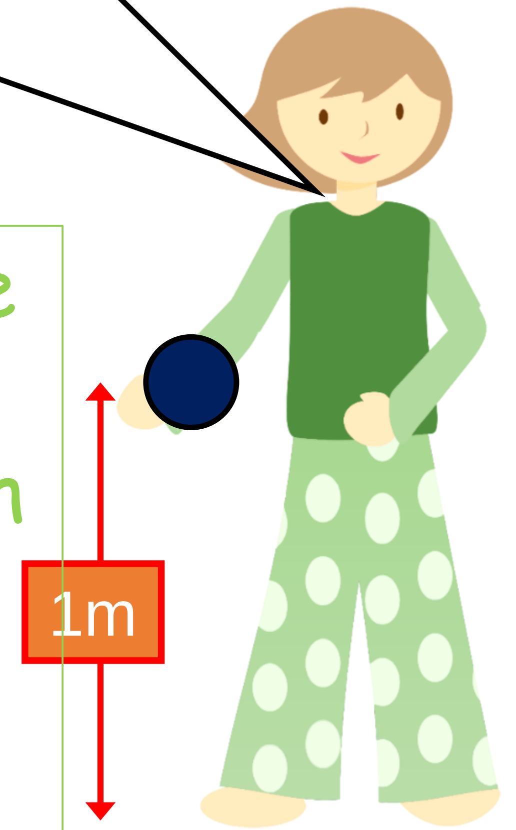
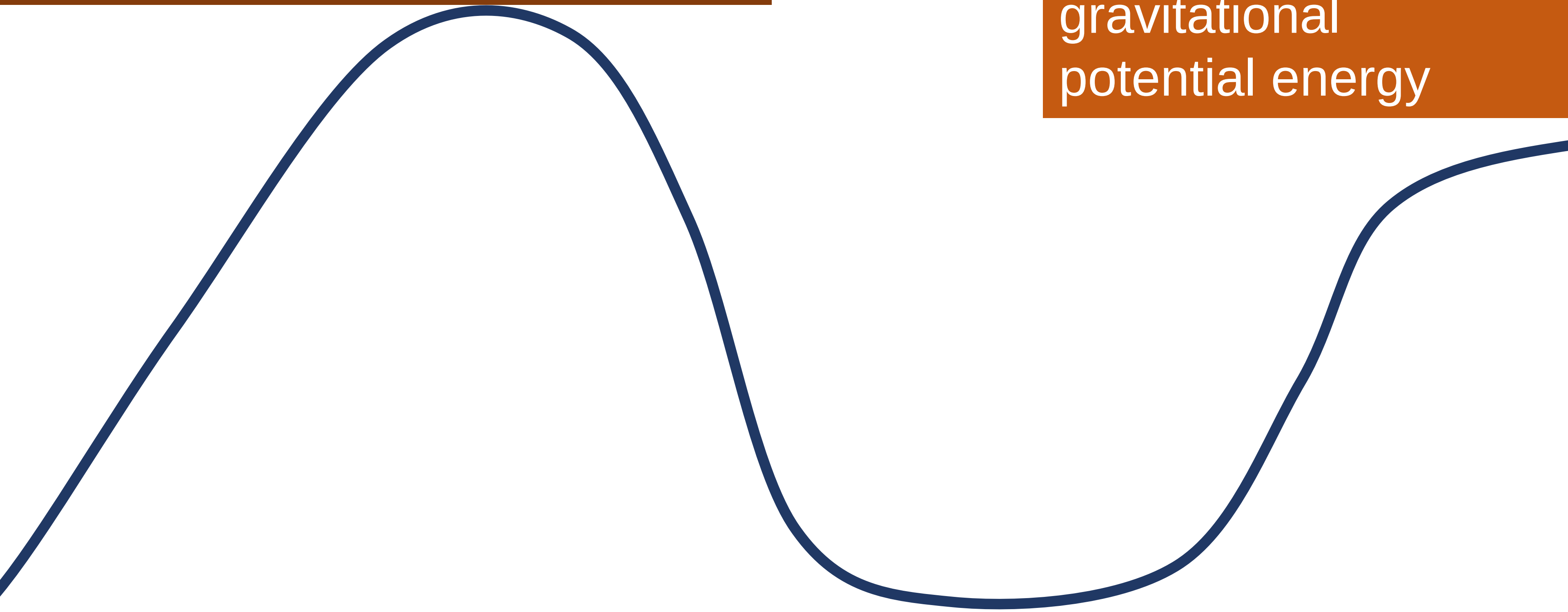
You get the same answer with SUVAT equations Try it!



Roller Coasters

1) Electrical energy is transferred into gravitational potential energy

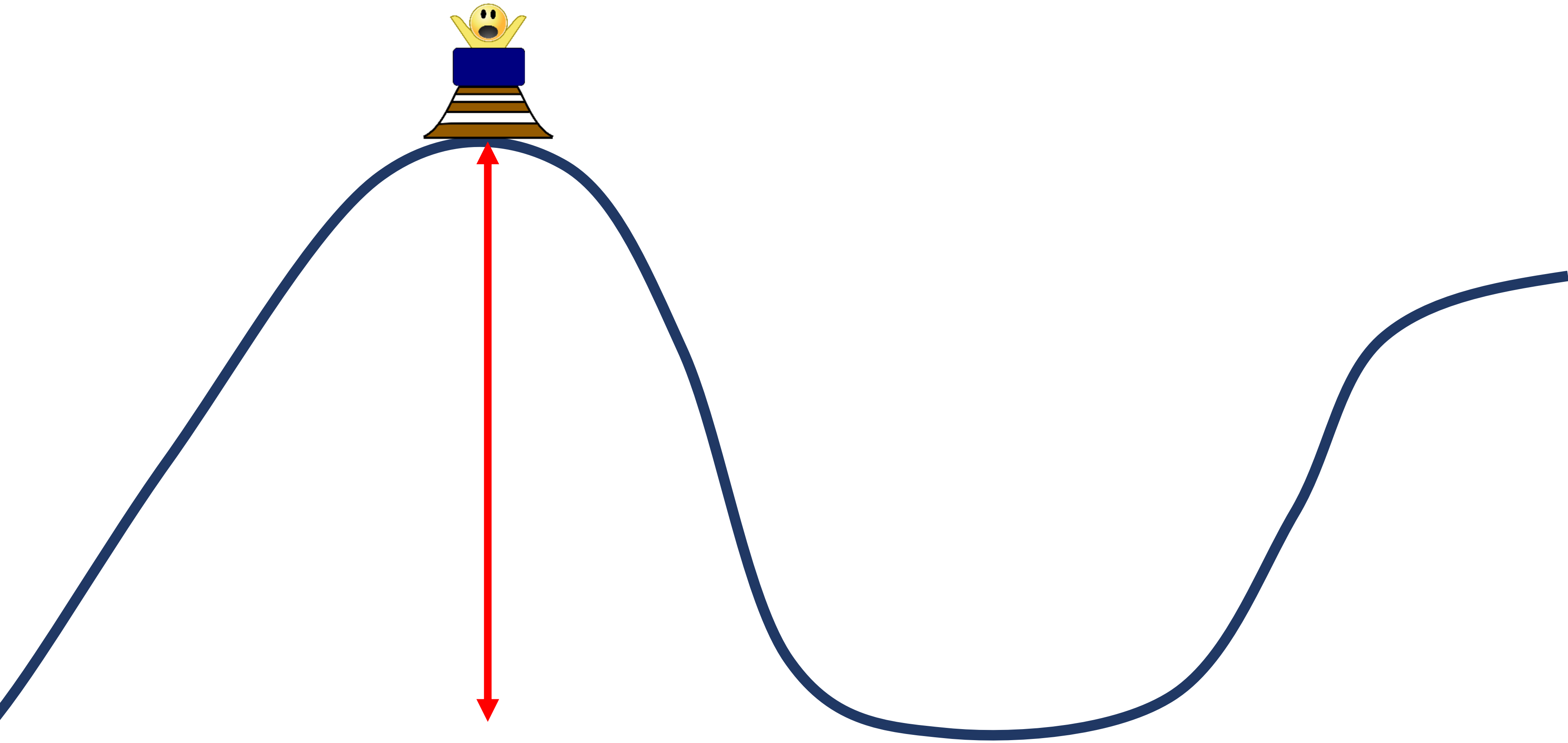
3) Kinetic energy is transferred back into gravitational potential energy



2) Gravitational potential energy is transferred into kinetic energy

Conservation of energy…

If the height of the drop was 100m and assuming there was a 100% conversion from gravitational to kinetic energy, how fast was the roller coaster car moving at the bottom of the ramp?



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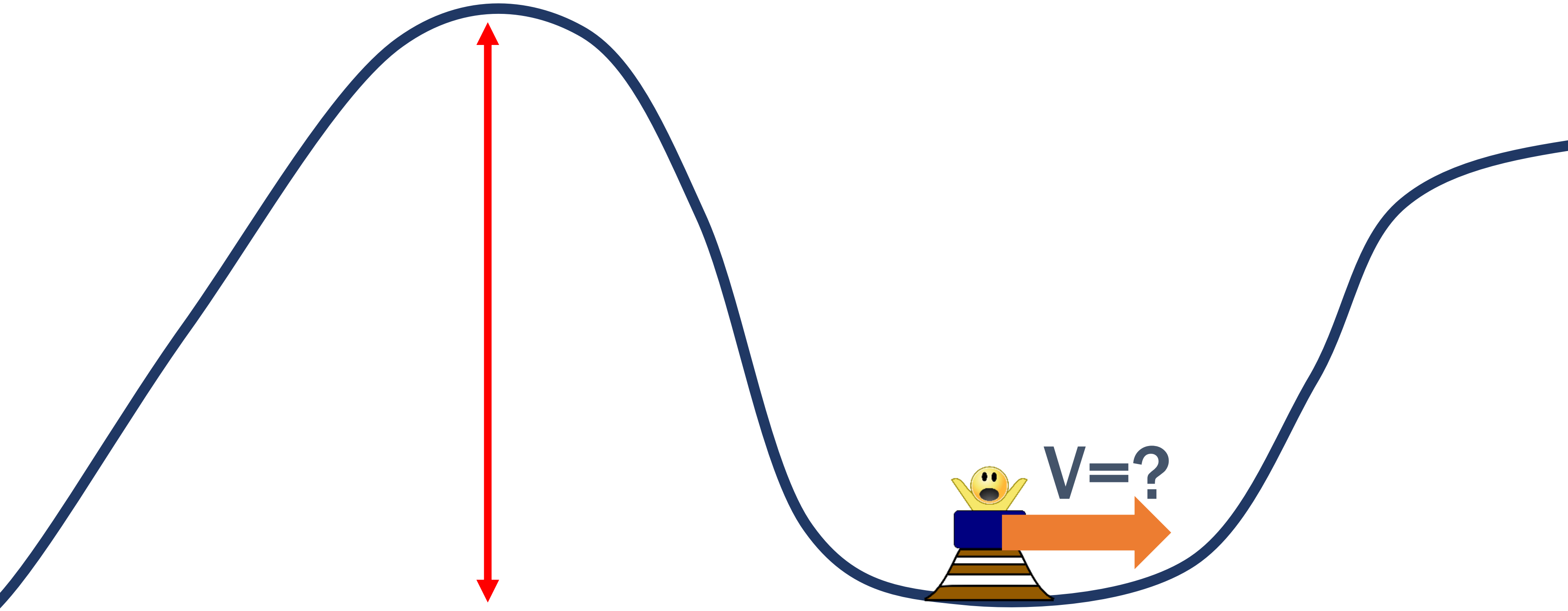

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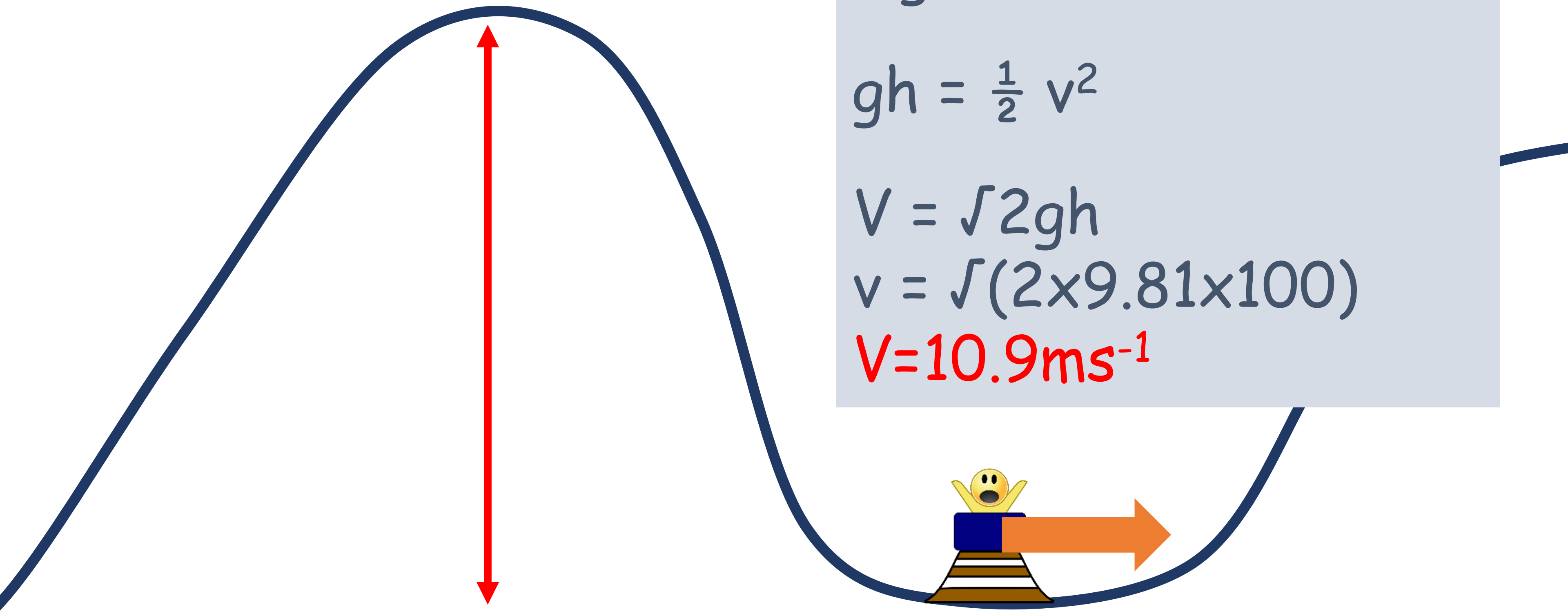

$mgh = 1/\ 2mv^2$

$gh = \frac{1}{2}\ v^2$

$V = \sqrt{2gh}$

$v = \sqrt{(2 \times 9.81 \times 100)}$

$V = 10.9ms^{-1}$

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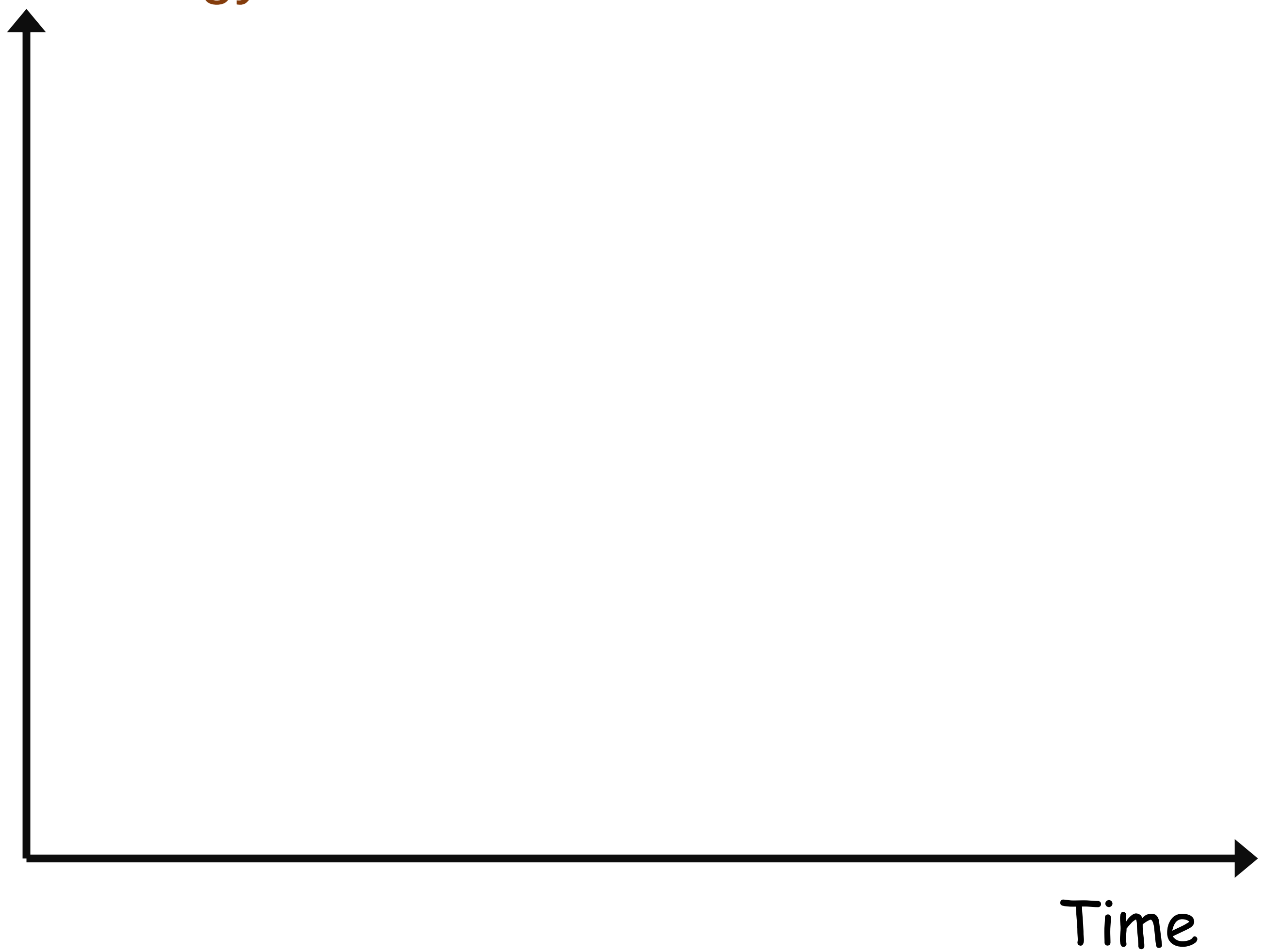
Conservation of Energy

Consider a bouncing ball:

Gravitational
Potential Energy



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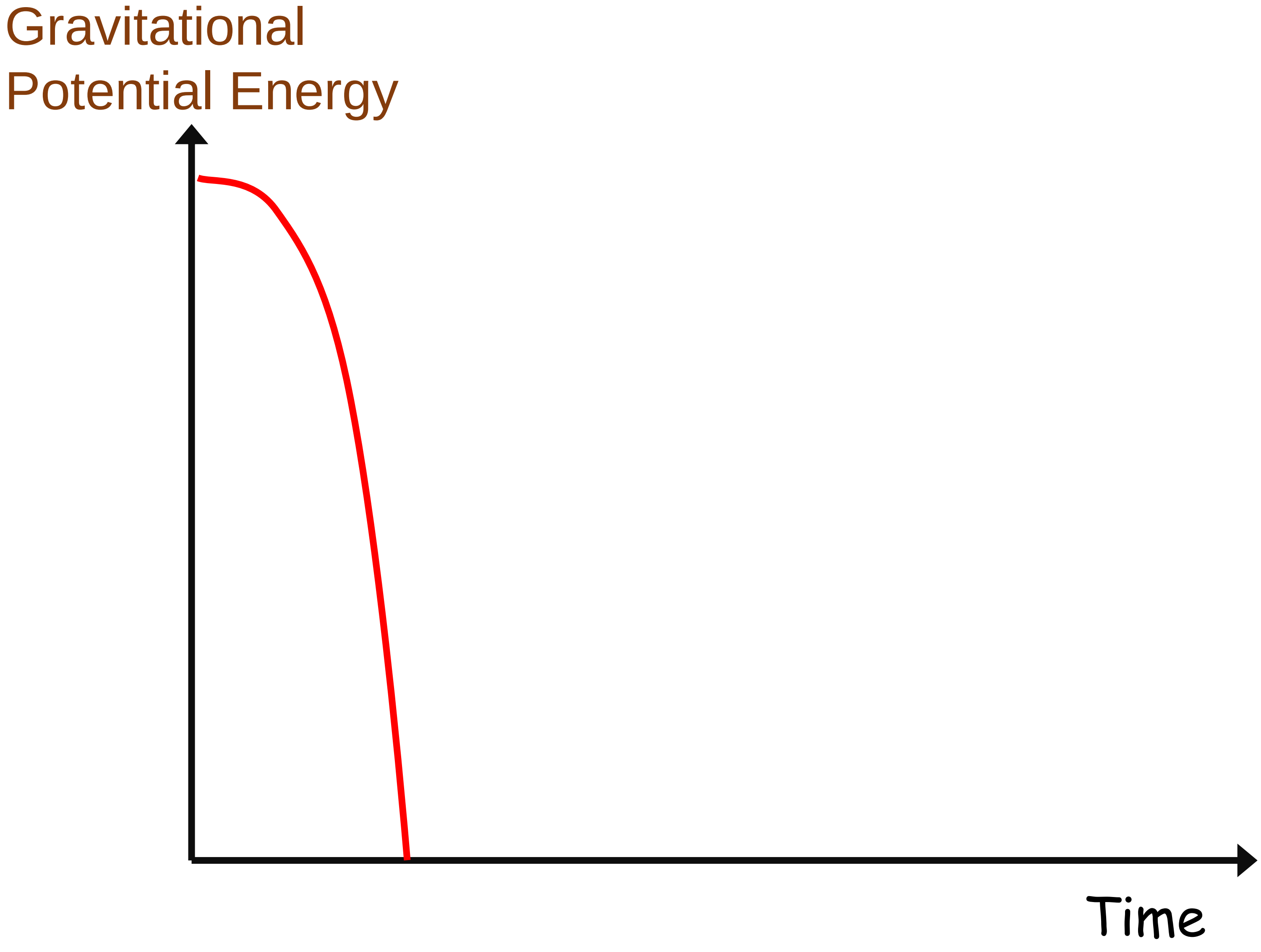

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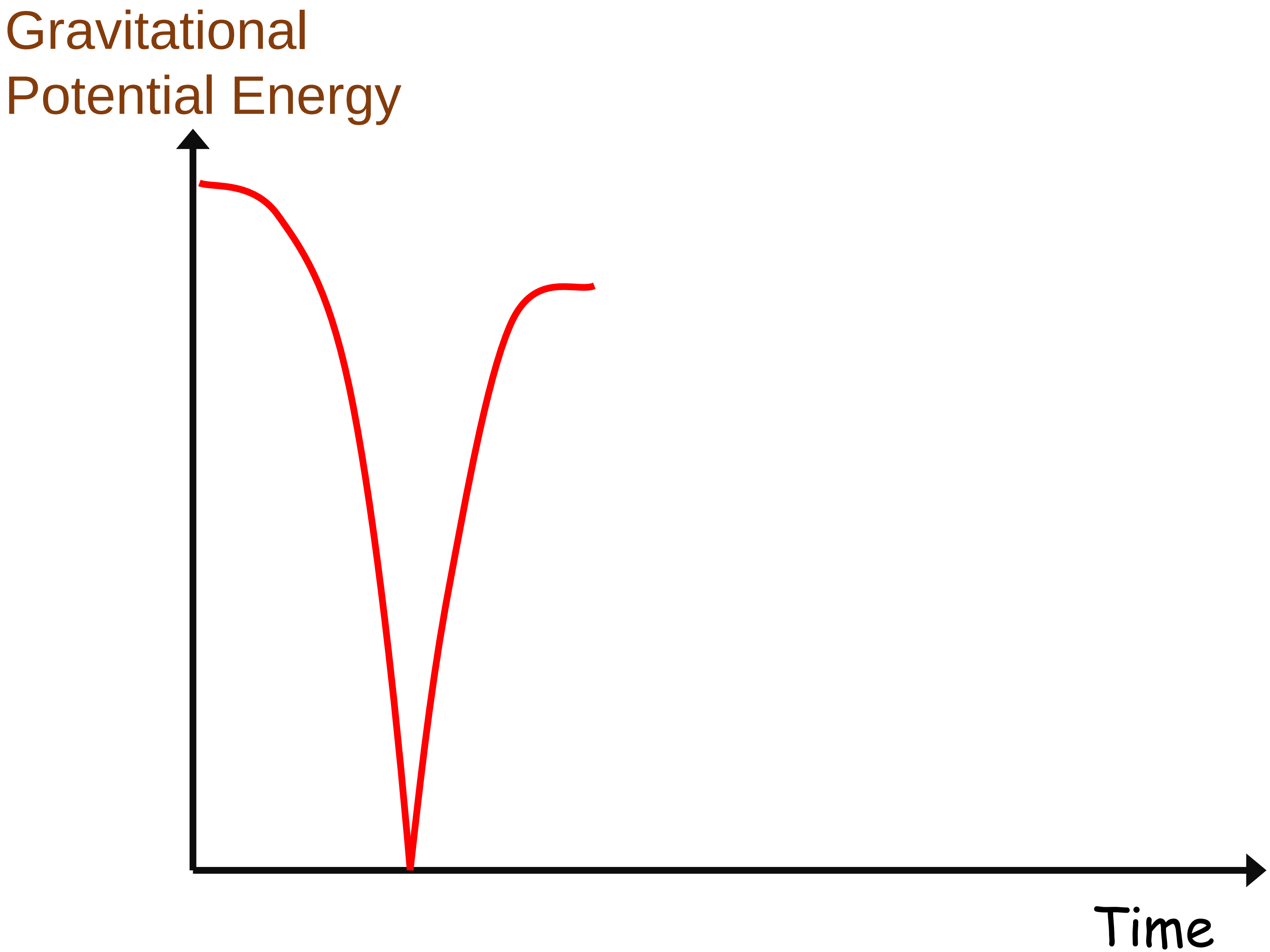

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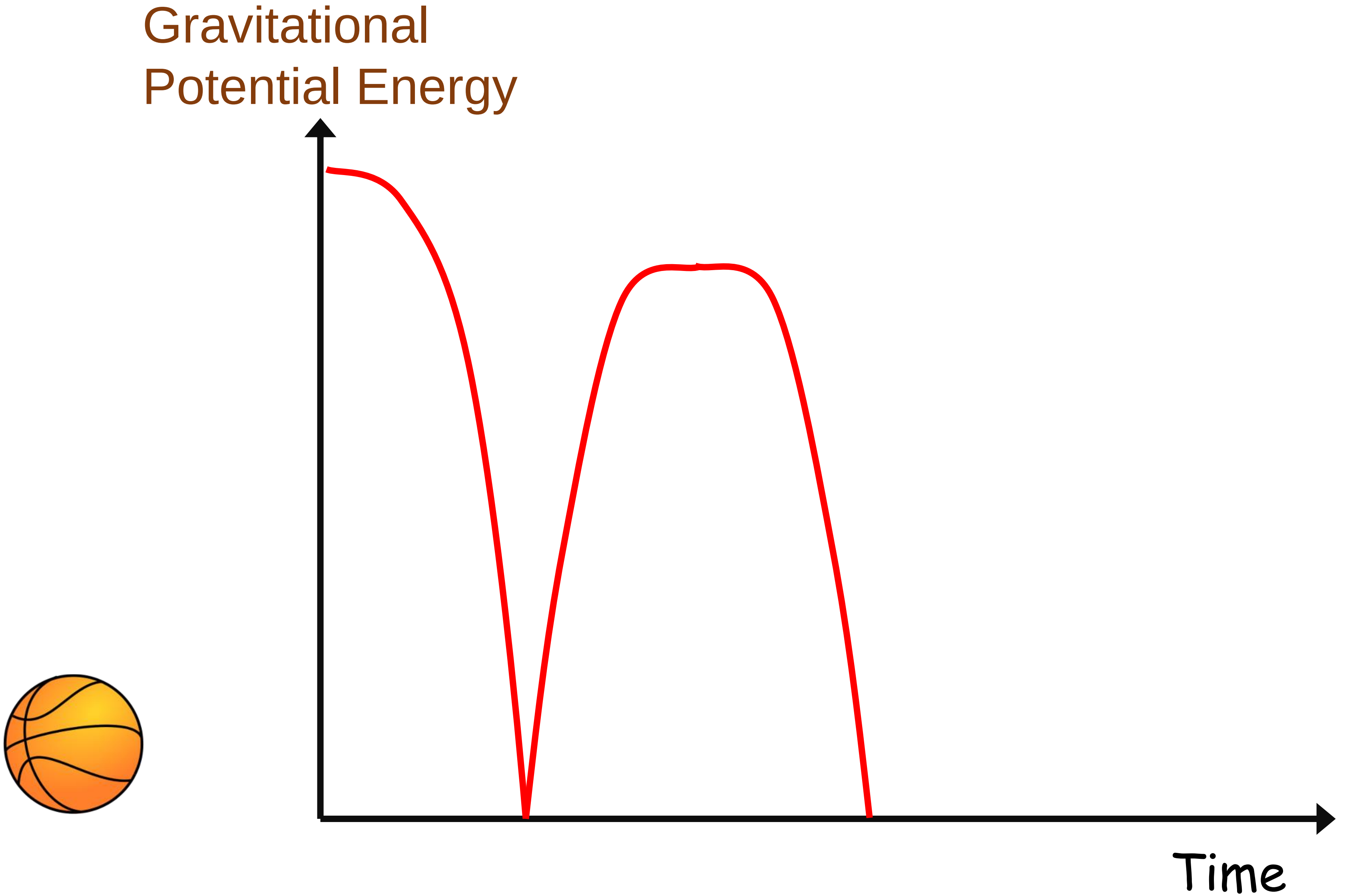

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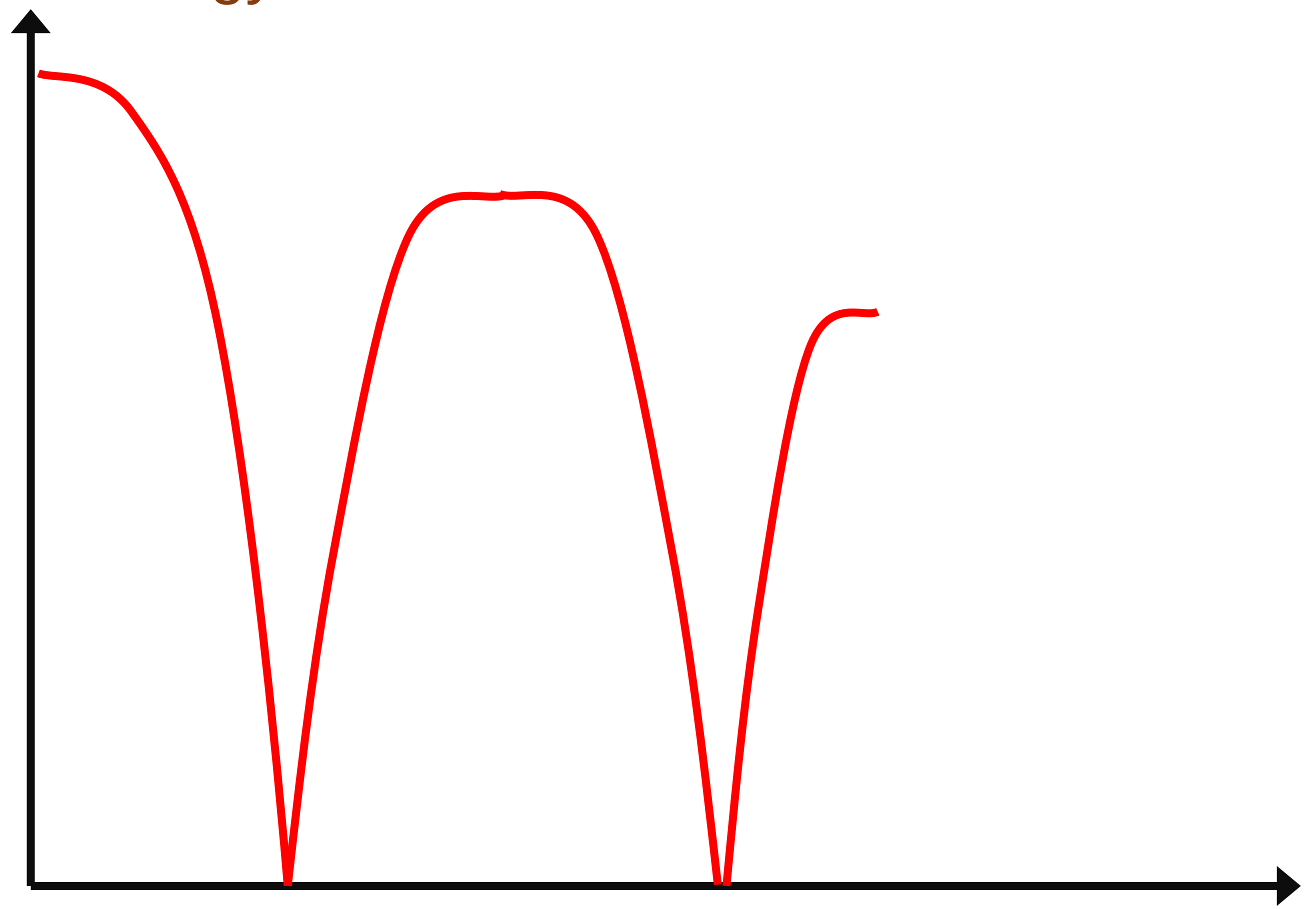

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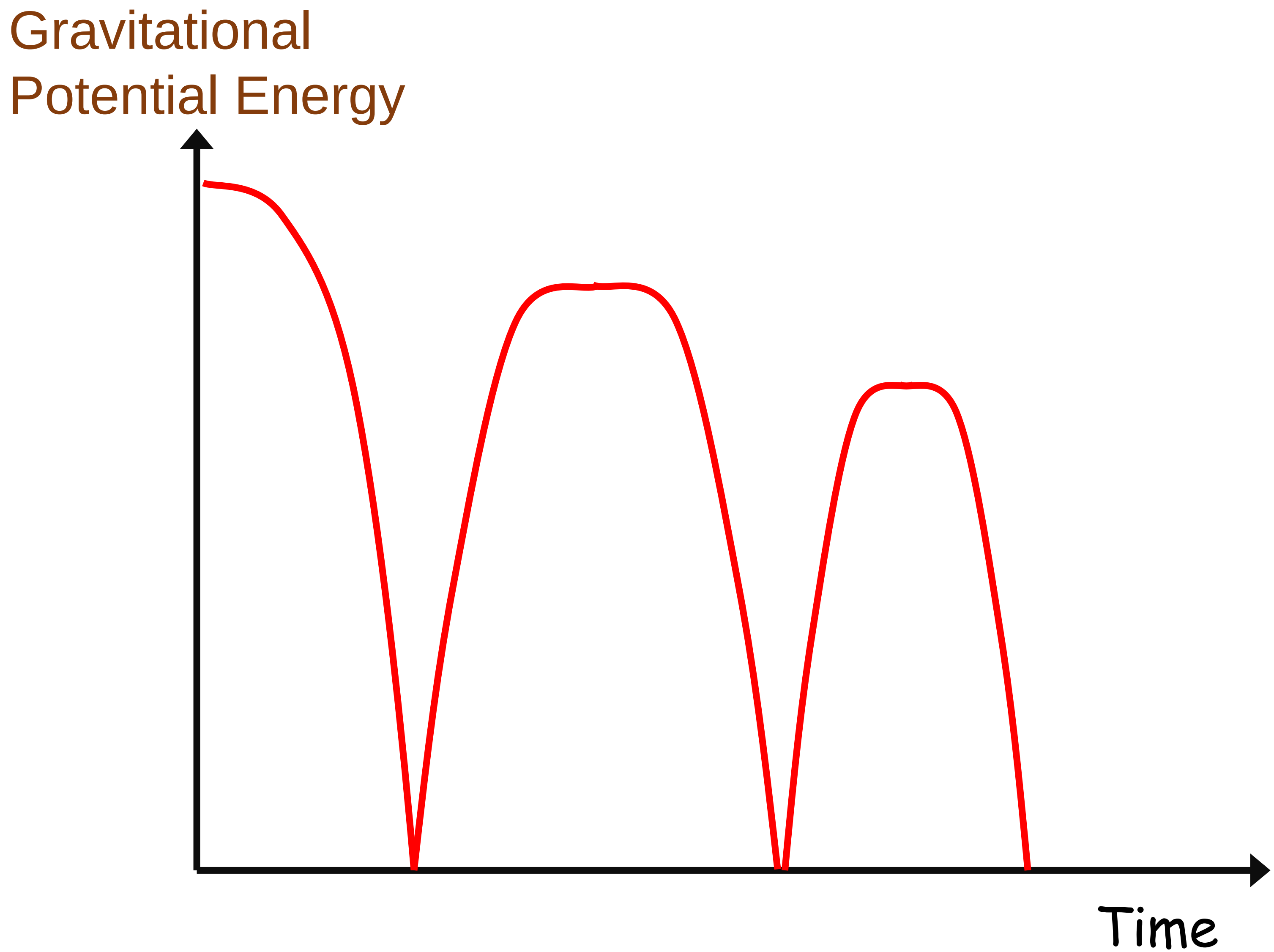

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Conservation of Energy

Consider a bouncing ball:

Kinetic Energy

Time

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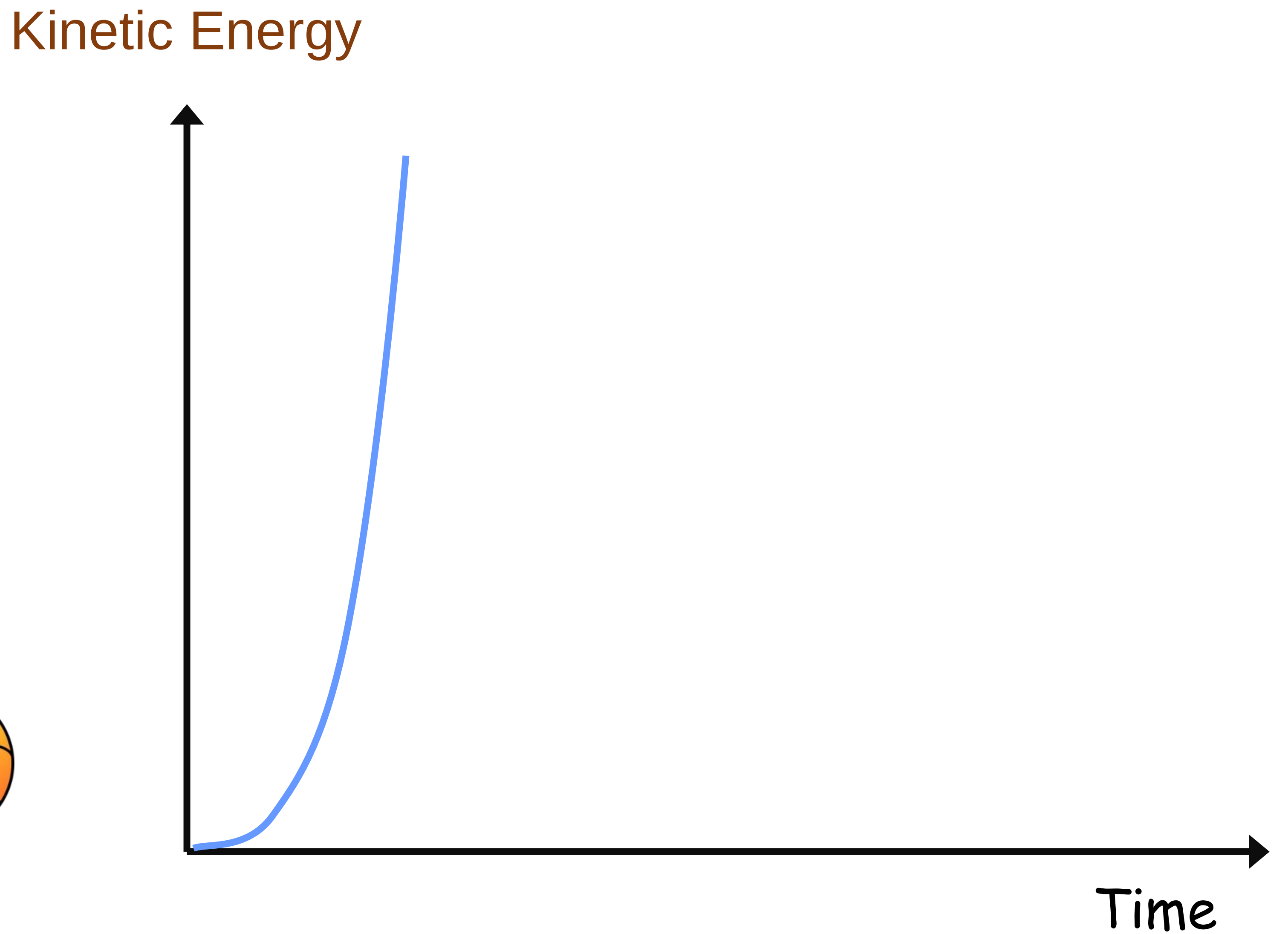
Conservation of Energy

Consider a bouncing ball:



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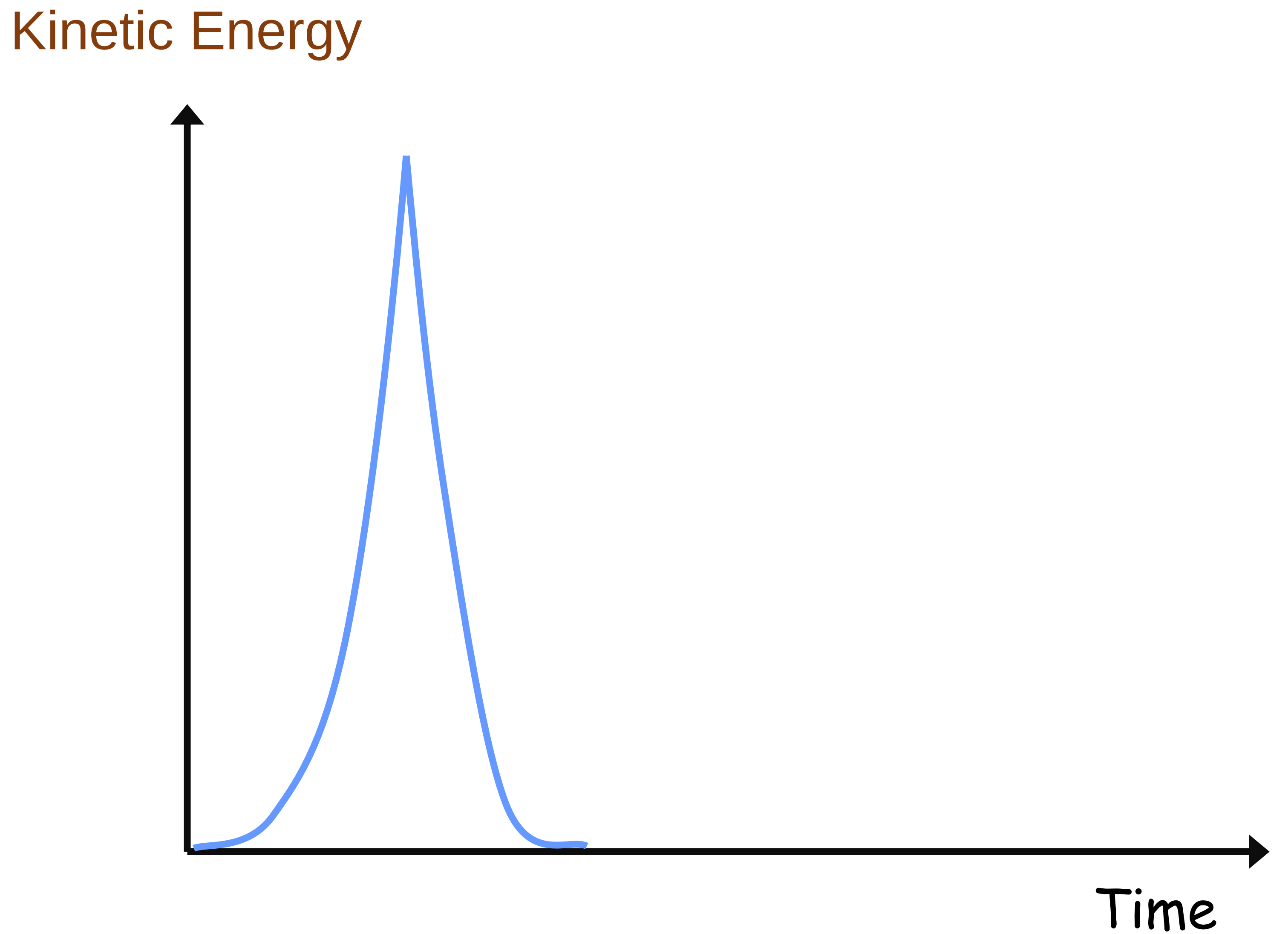

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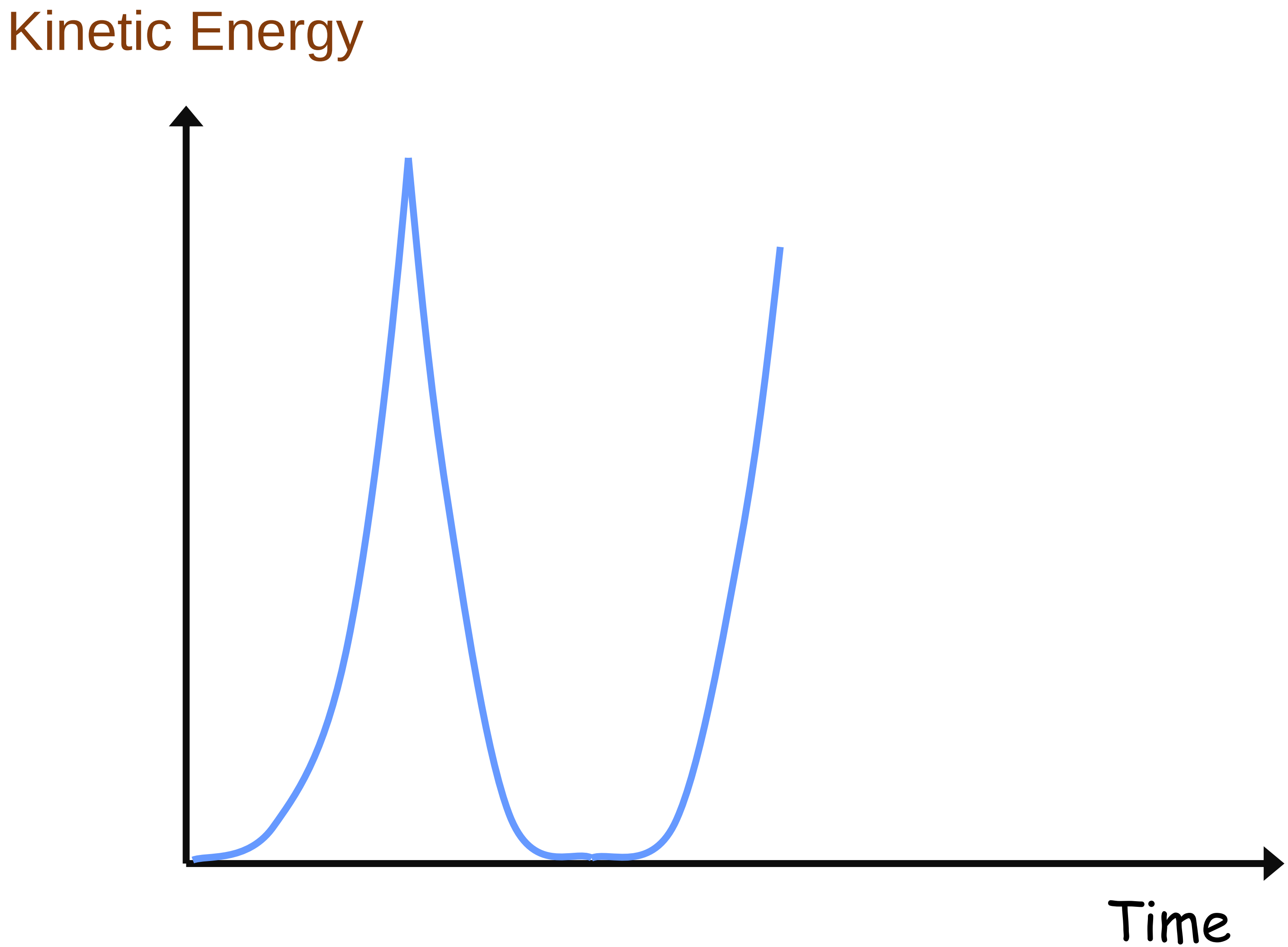
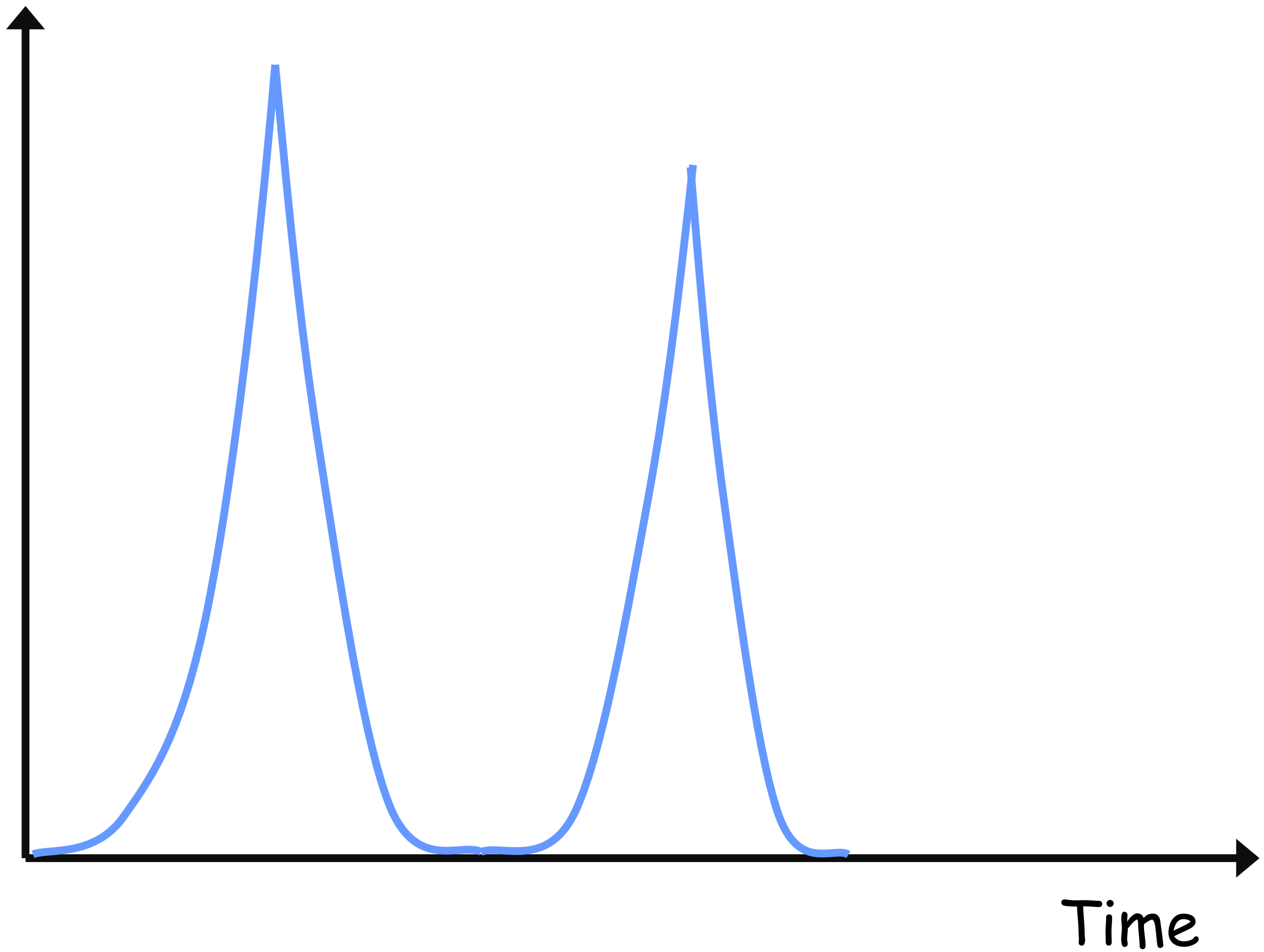


Conservation of Energy

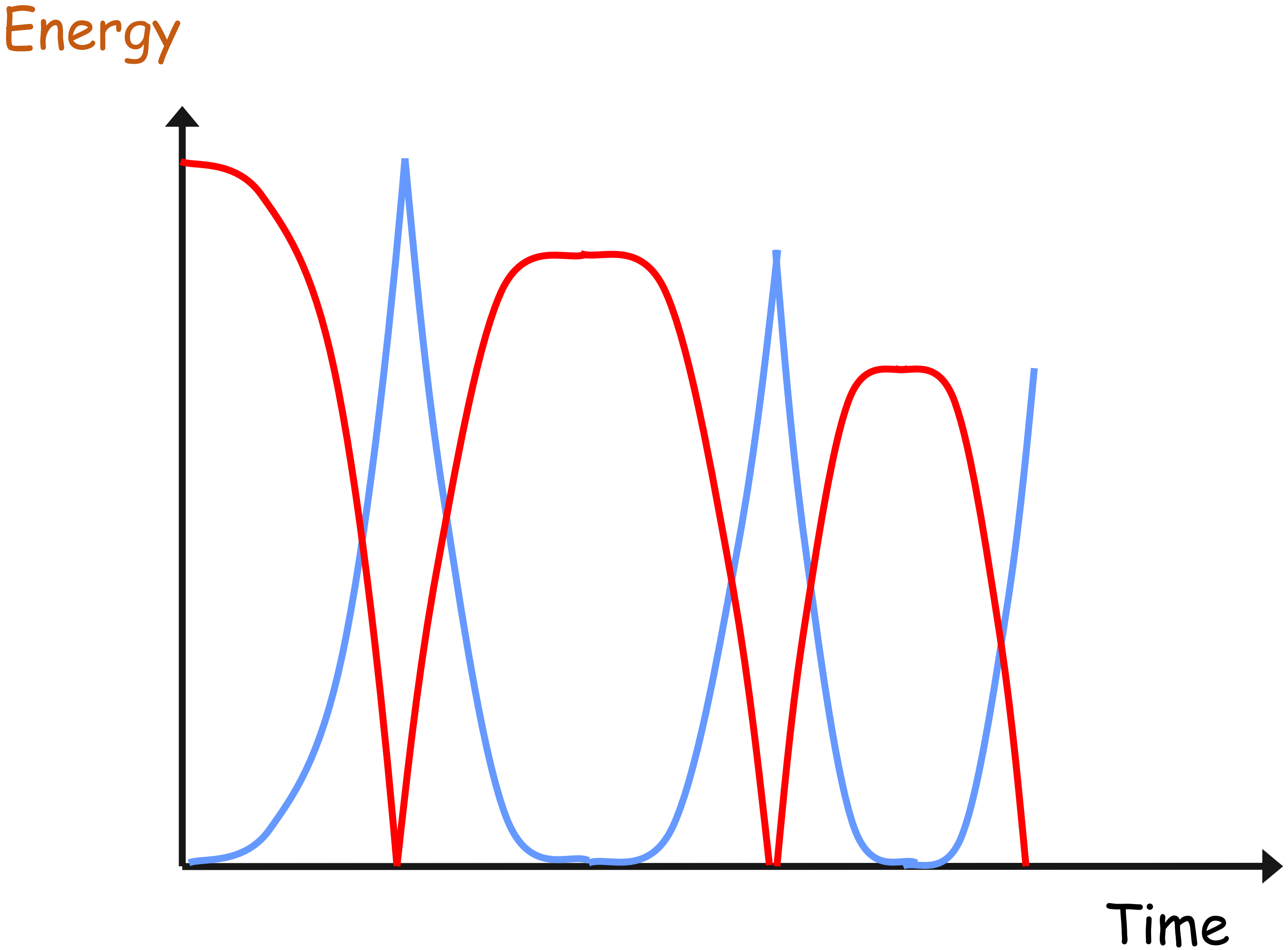
Consider a bouncing ball:

Kinetic Energy



Conservation of Energy

Now put these graphs together:



Conservation of Energy

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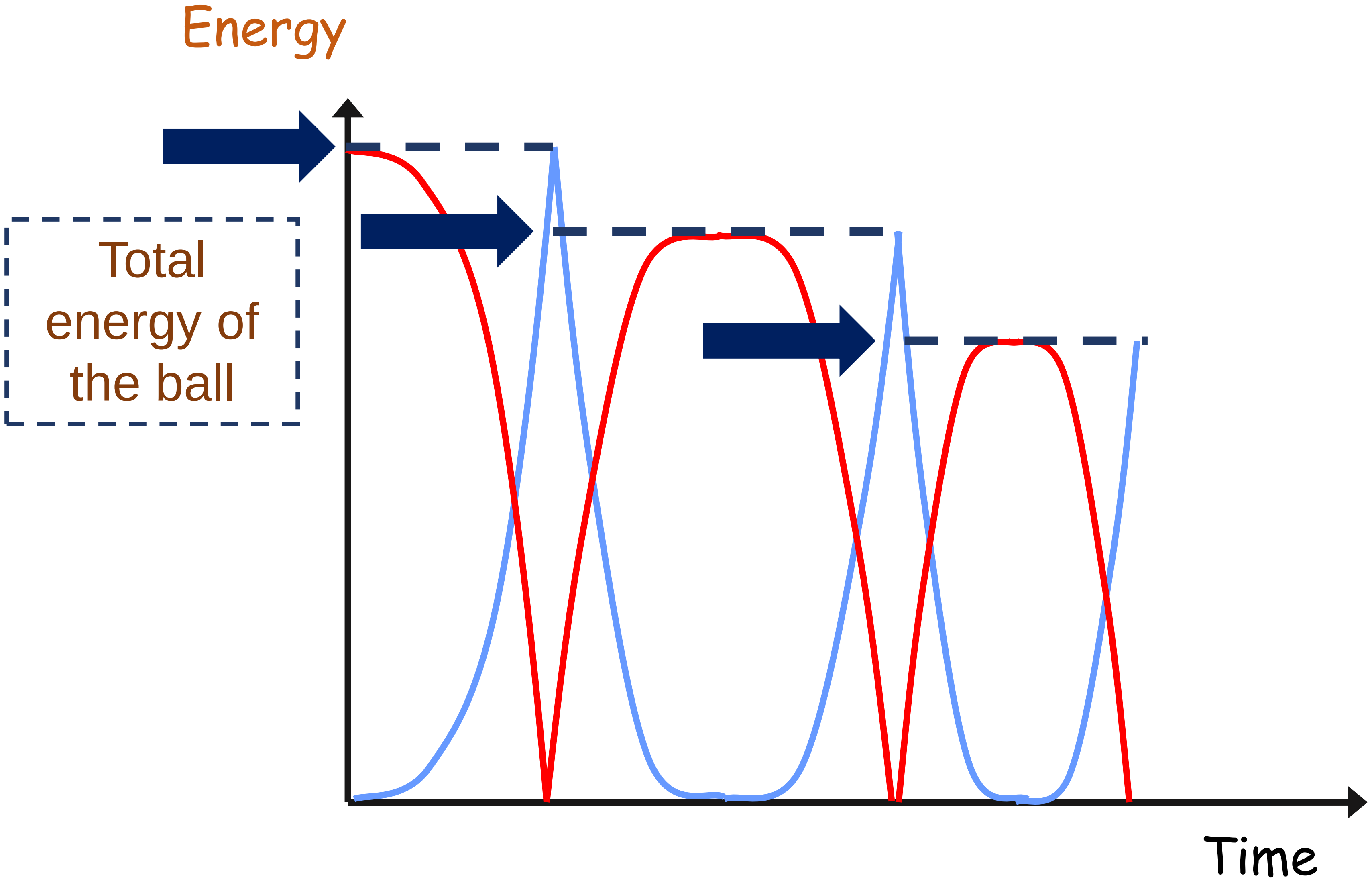
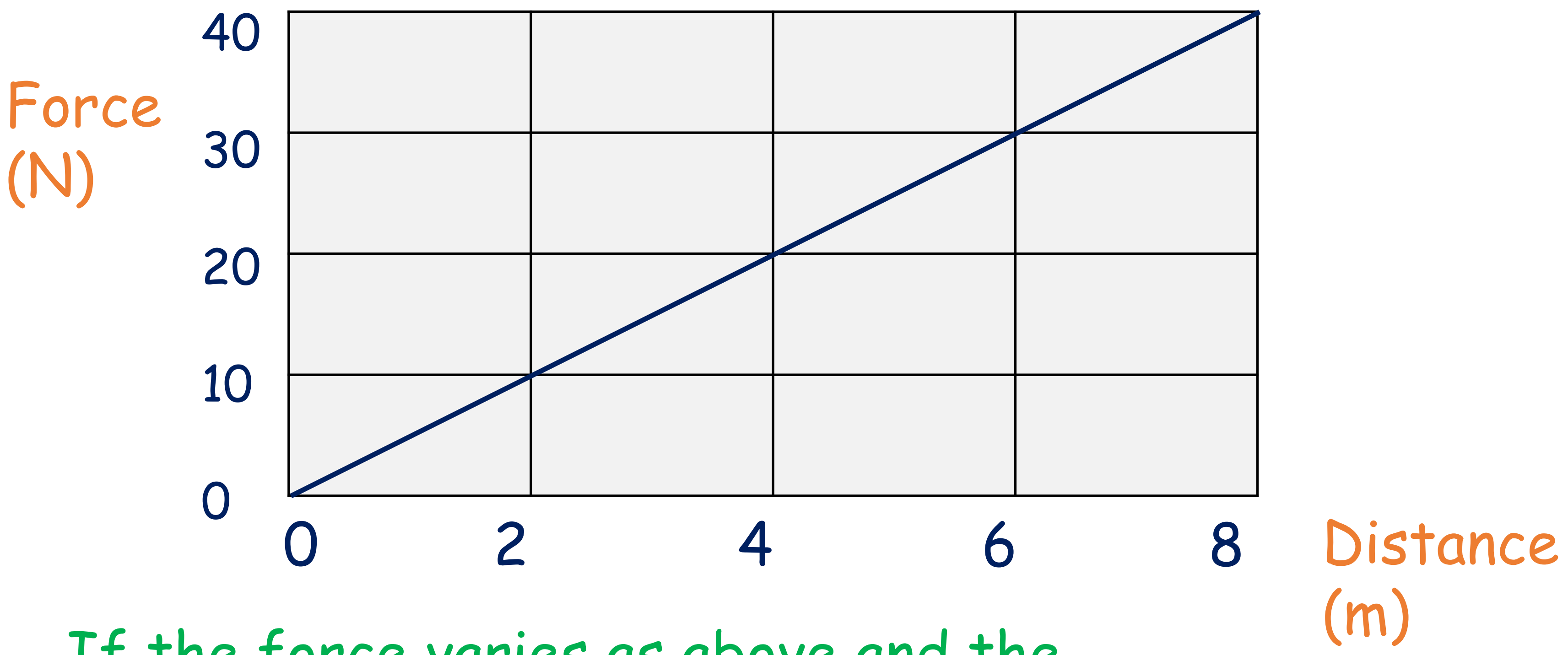


Work done

Work done (in joules) is simply the force needed to move an object multiplied by the distance moved in the direction of the force:

$$\Delta W = F\Delta s$$



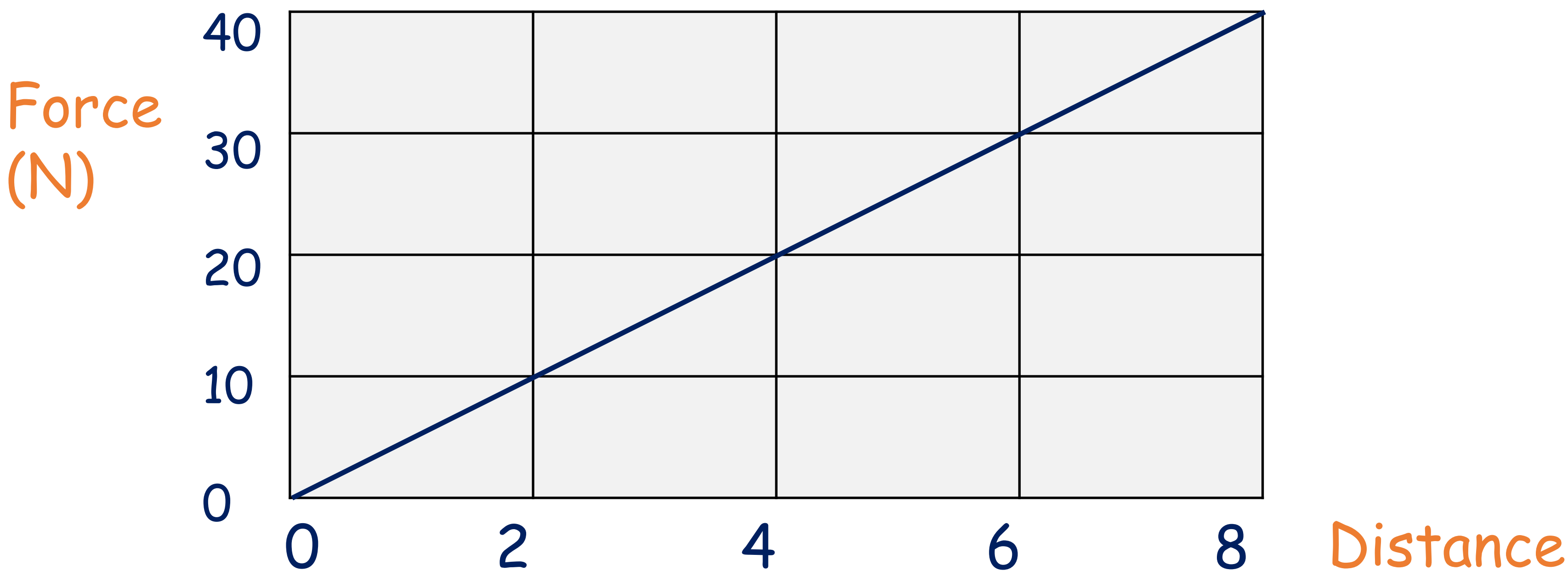
If the force varies as above and the distance is 8m, how much work is done?

Work done

When the force varies, we have to use the average force

To find work done

$$\Delta W = F_{AVE} \Delta s$$



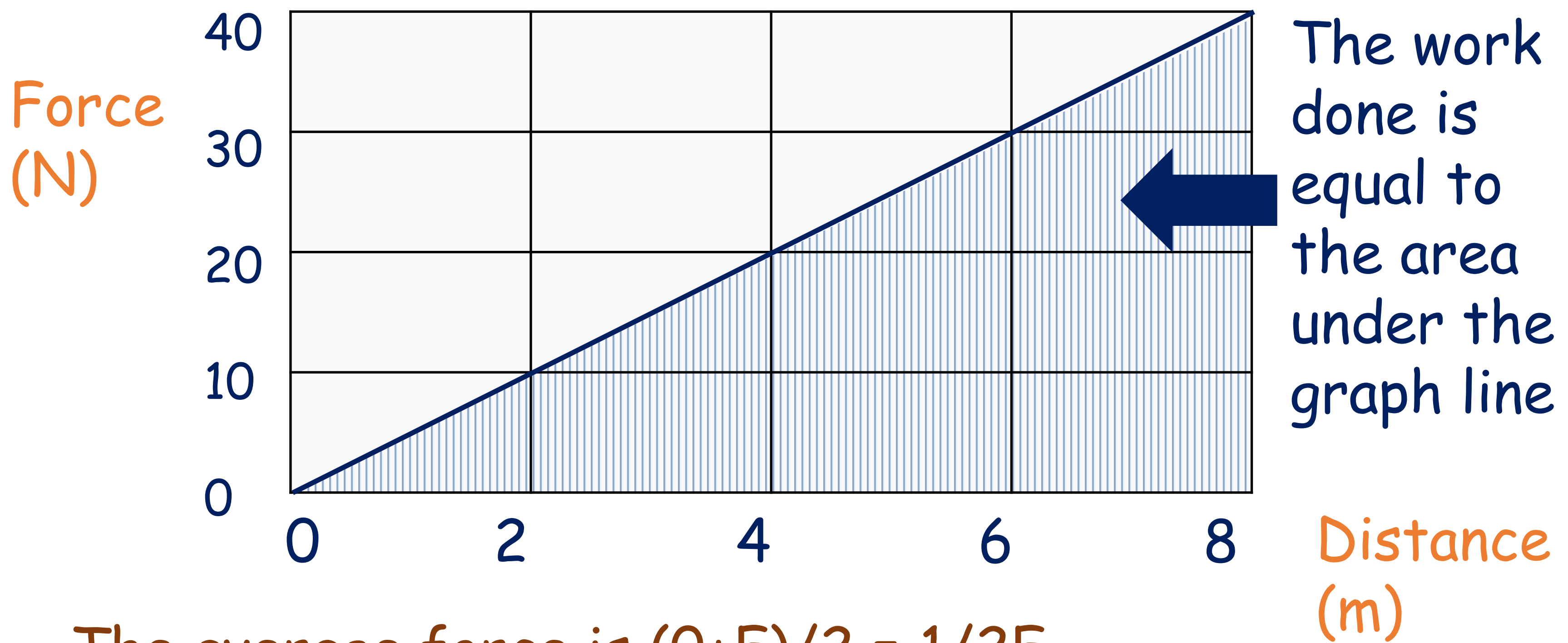
The average force is (0+F)/2 = 1/2F

The work done is therefore 1/2Fs

Work done

When the force varies, we have to use the average force to find work done

$$\Delta W = F_{AVE}\Delta s$$



The average force is (0+F)/2 = 1/2F
The work done is therefore = 1/2Fs

Power

Power (in watts) is “the rate of doing work”:

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

Also, using our “work done” equation: $\Delta W = F\Delta s$

$$P = \frac{\Delta W}{\Delta t} = \frac{F\Delta s}{\Delta t}$$

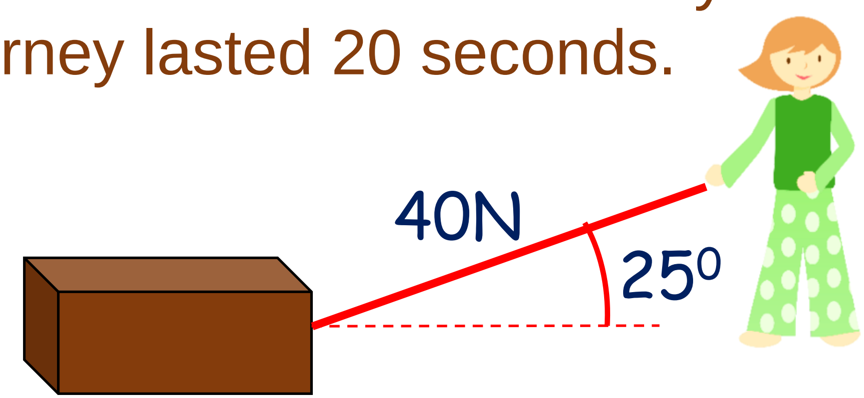
…therefore $P = Fv$

Questions on work and power

1) Ryan pushes John in the direction of a cliff. If he uses a force of 50N and he moves Dan 10m in 5s calculate the work done and Ryan's power rating.

2) Alice runs up some stairs and has a power rating of 700W while she does so. If he does it in 4 seconds and her weight is 550N, calculate how high the stairs are.

3) A woman pulls a block of wood at an angle of 25^0 to the horizontal and uses a force of 40N. If the distance travelled horizontally is 6m calculate the work done by the woman and her power if the journey lasted 20 seconds.



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Efficiency revision

Efficiency is a measure of how much USEFUL energy you get out of an object from the energy you put INTO it.

For example, consider a computer:

Electrical Energy (100J)

Light (40J)

Sound (20J)

Heat (?)

$$\text{Efficiency} = \frac{\text{Useful energy out}}{\text{Energy in}} \times 100\%$$

Some examples of efficiency…

1) 4000J of electrical energy are put into a motor. The motor converts this into 1500J of movement energy. How efficient is it?

2) A laptop can convert 500W of electrical power into 270W of light and sound power. What is its efficiency? Where does the rest of the energy go?

3) A steam engine is 25% efficient. If it delivers 30,000W of movement power, how much chemical energy was put into it every second?