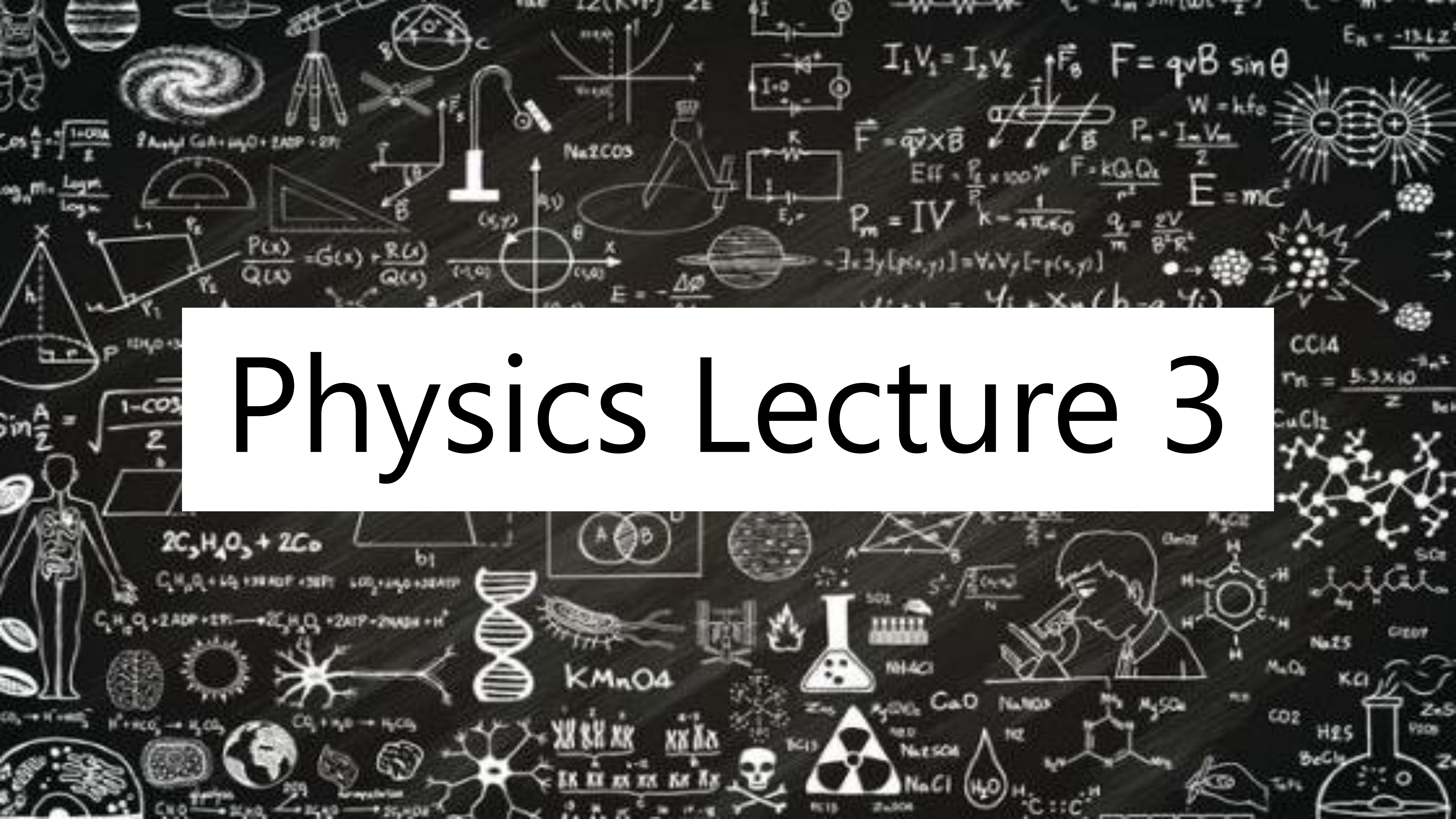
Physics Lecture 3



2: Key protocols

Watch the lecture with your microphone and camera off.

The lecture is being recorded

Post any questions the meetings conversation.

During slides with a black background you should listen and take notes.

During slides with a white background you should complete the task.

3: Questions?

- During the lecture → post on the meeting conversation
  → turn on your microphone and speak

- After the lecture → email me
- rowes@salesian.hants.sch.uk

?

4: Tasks at home – One Note

- More resources in One Note
- Complete the post-lecture tasks in OneNote Class Notebooks.
- Use the page titled **2020-05-12 Mechanics**
- Tasks will be teacher reviewed.

5. Introduction to Mechanics

- https://qualifications.pearson.com/en/qualifications/edexcel-a-levels/physics-2015.html#%2Ftab-ASlevel

6: Objectives You should:

- Be able to use the equations for uniformly accelerated motion in one dimension
- Be able to draw and interpret displacement/time, velocity/time and acceleration/time graphs
- Know the physics quantities derived from the slopes and areas of these graphs
- Understand scalar and vector quantities and know examples of each type
- Understand vector notation

7: Objectives continued – You should

- be able to use the equation $\sum F = ma$, and understand how to use this equation in situations where m is constant (Newton's second law of motion), including Newton's first law of motion where $a = 0$, objects at rest or travelling at constant velocity. Use of the term terminal velocity is expected

8: Estimate:

- The speed at which a train travels between Farnborough Main and London Waterloo

- Distance = 64km
- Time = 40 mins = 0.67 hours

- Speed = 95 kmh^{-1} (not km/h)

Do we mean “average” or “instantaneous”
What “average” do we mean (mean, mode, median)?

9: Terminology

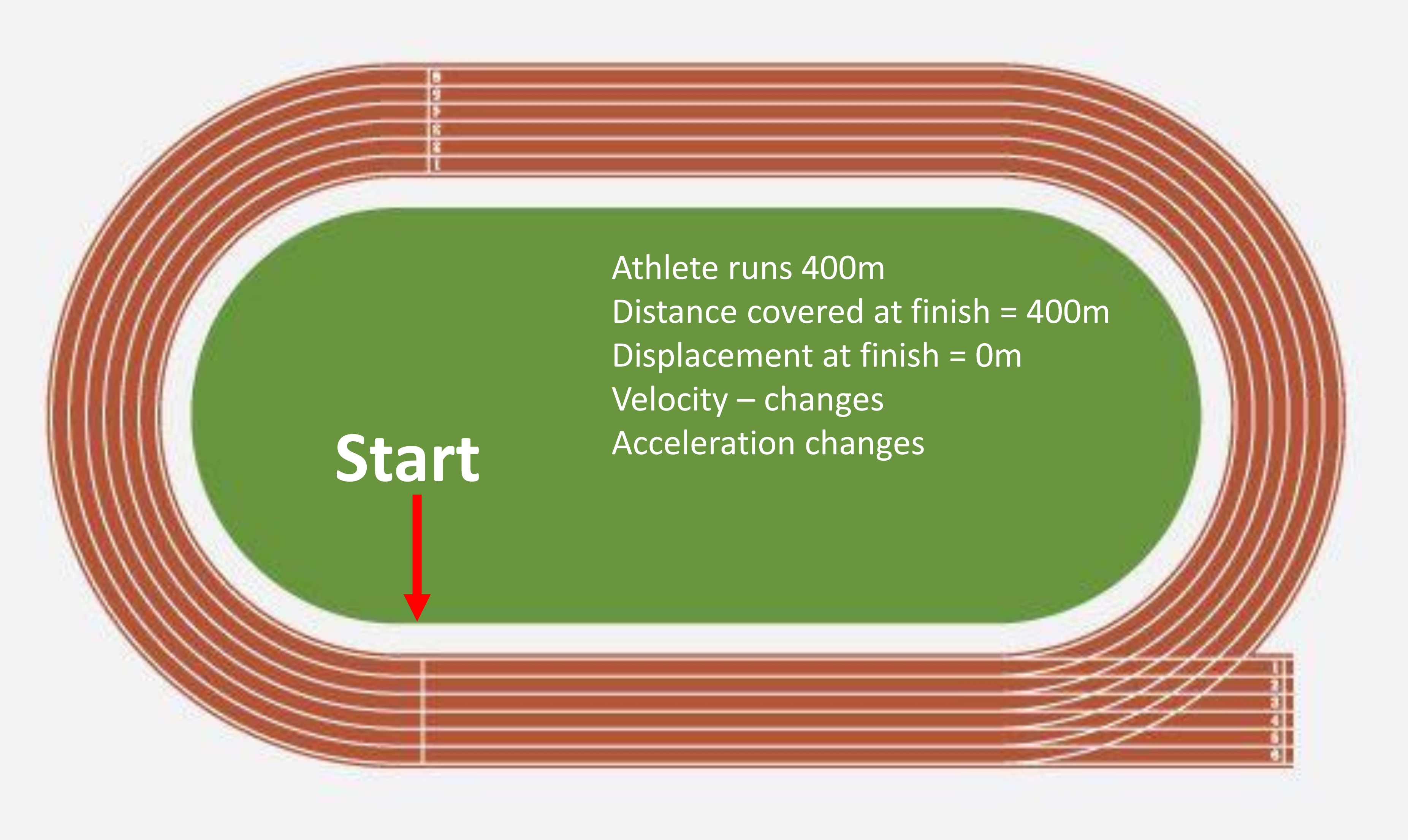
In physics, we must be very careful and precise with our wording:

- Mass or weight?
- Velocity or speed?
- Error or uncertainty?

Try not to use not use words such as “amount” or “quantity”. These words can always be defined more precisely

10: Definitions

- Distance – total ground covered (scalar)
- Displacement (s) – vector measurement of distance in a defined direction
- Velocity (v) – rate of change of displacement (vector)
- Speed – magnitude of velocity (scalar)
- Acceleration (a) – rate of change of velocity (vector)


Athlete runs 400m
Distance covered at finish = 400m
Displacement at finish = 0m
Velocity – changes
Acceleration changes
Start

12: The SUVAT equations

- $s = \frac{1}{2}(u + v)t$
- $v = u + at$
- $s = ut + \frac{1}{2}at^2$
- $v^2 = u^2 + 2as$

s = distance/displacement (m)

u = initial velocity/speed (ms^{-1})

v = final velocity/speed (ms^{-1})

a = acceleration (ms^{-2})

t = time (s)

13: SUVAT Equations - Important

- You can only use these equations if the acceleration of a body is constant
- Questions are often set in the context of a body falling under the influence of gravity
- Acceleration due to gravity is constant: $g = 9.81\ ms^{-2}$
- We usually ignore air resistance

14: Calculation

An electron in an X-ray machine is accelerated from rest to half the speed of light in 1.7×10^{-15} s. Calculate:

(a) The speed the electron reaches in ms^{-1}

(b) The acceleration the electron experiences

Hint: which of s, u, v, a and t do you know?

which equations can be used to find the missing values?

15: Answers

Question (a)

The speed of light is 3.0×10^{8} ms^{-1}

So half the speed of light is
1.5×10^{8} ms^{-1}

Question (b)

s = unknown

u = 0

v = 1.5×10^{8} ms^{-1} from Q(a)

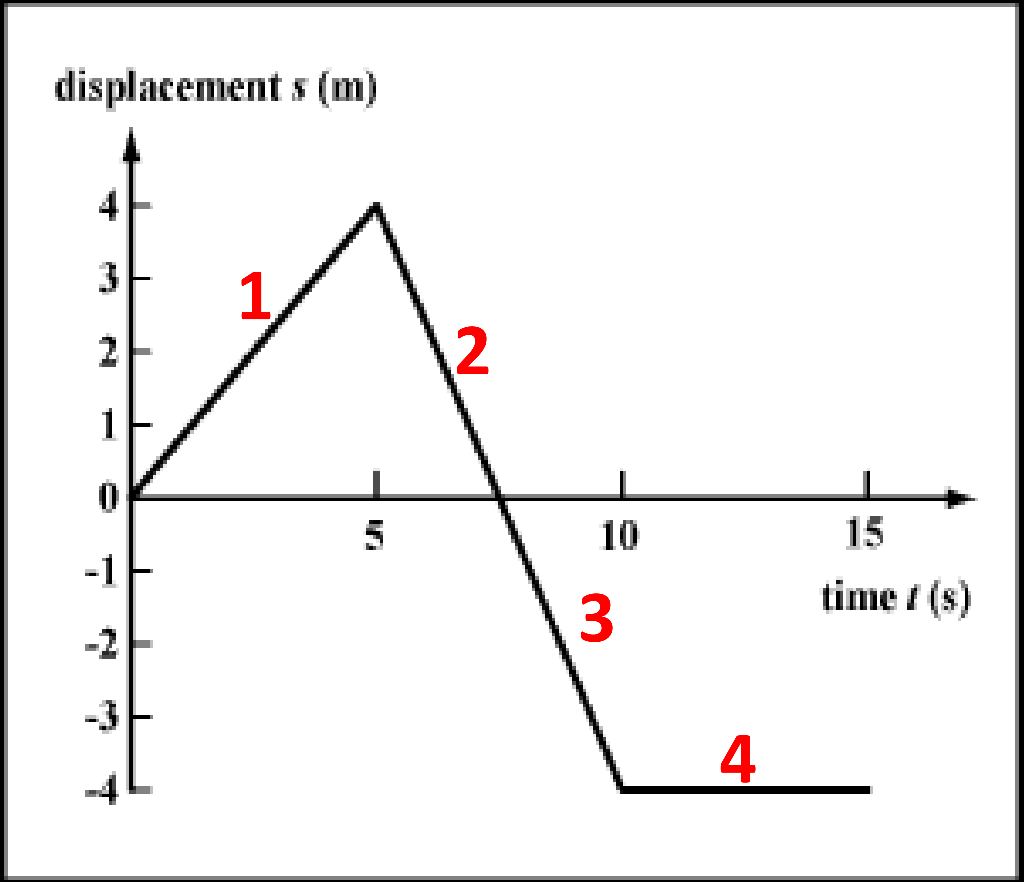
a = value sought

t = 1.7×10^{-15} s

Use $v = u + at$

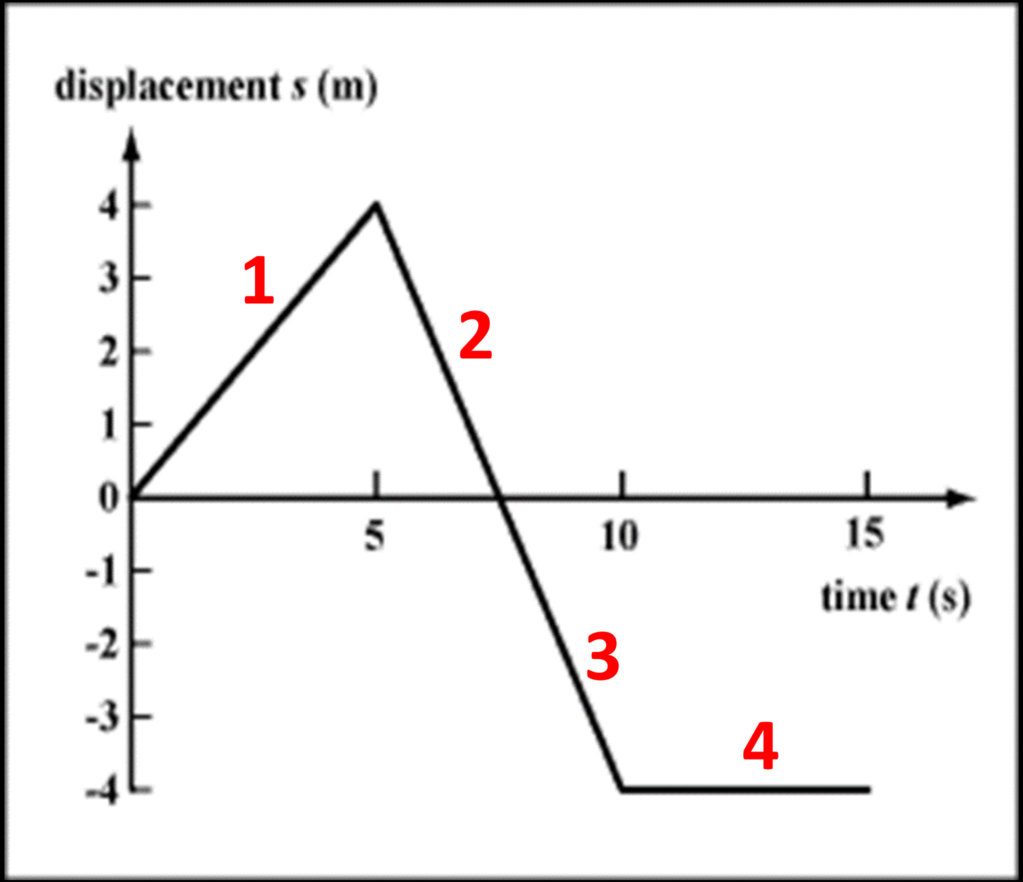
Answer = 8.8×10^{22} ms^{-1}

16: What does this s-t graph show?



- 0 on the vertical axis is the starting point
- Section 1 – the body travels away from 0 for 5 seconds at a constant velocity
- Section 2 – the body travels towards 0 for 2.5 seconds at a constant velocity
- Section 3 – the body moves away from 0 for 2.5 seconds at a constant velocity
- Section 4 – the body is -4m from 0 and is at rest

17: Information from s-t graphs



- Velocity = gradient of line
- In section 1, the gradient is 4/5, so the velocity is 0.8 ms^{-1}
- In section 2, the velocity is negative as the body is moving back towards its starting point

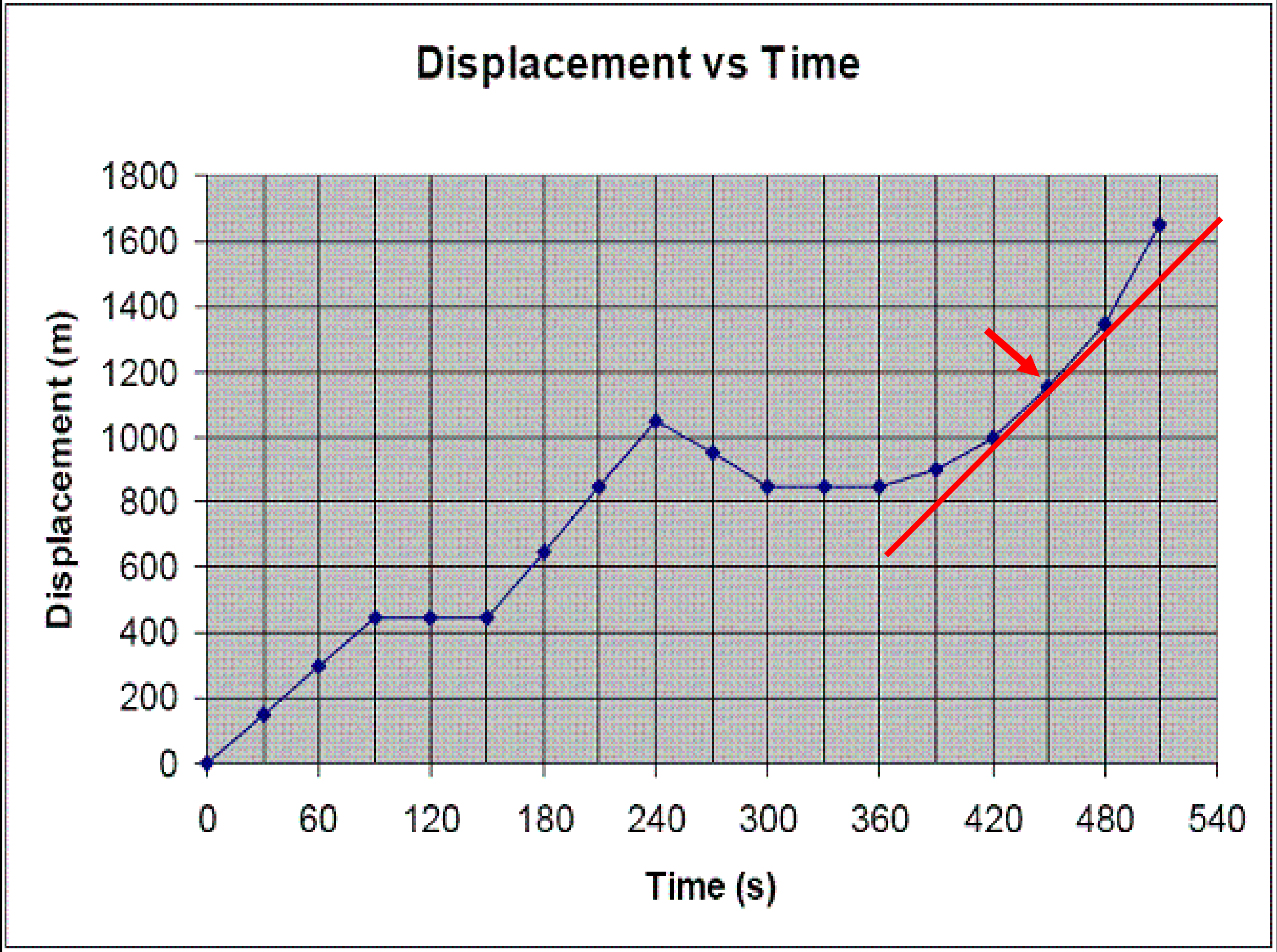
18: Speed and velocity from s-t graphs

$$v = \frac{\text{displacement}}{\text{time}}$$

$$v = \frac{\Delta s}{\Delta t}$$

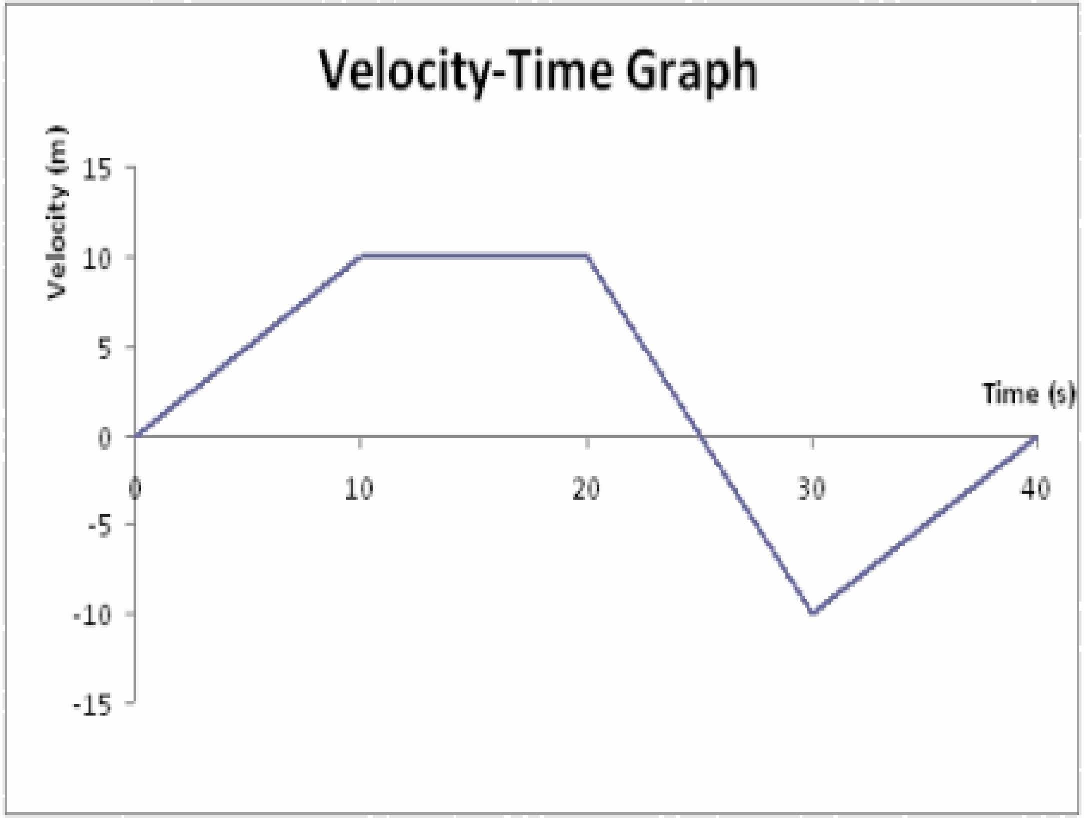
What is the velocity at

1. 60s?
2. 330s?
3. 450s?



19: Velocity–time graphs (3 minutes)

Describe, in as much detail as possible, the motion of the body as displayed by the graph below:

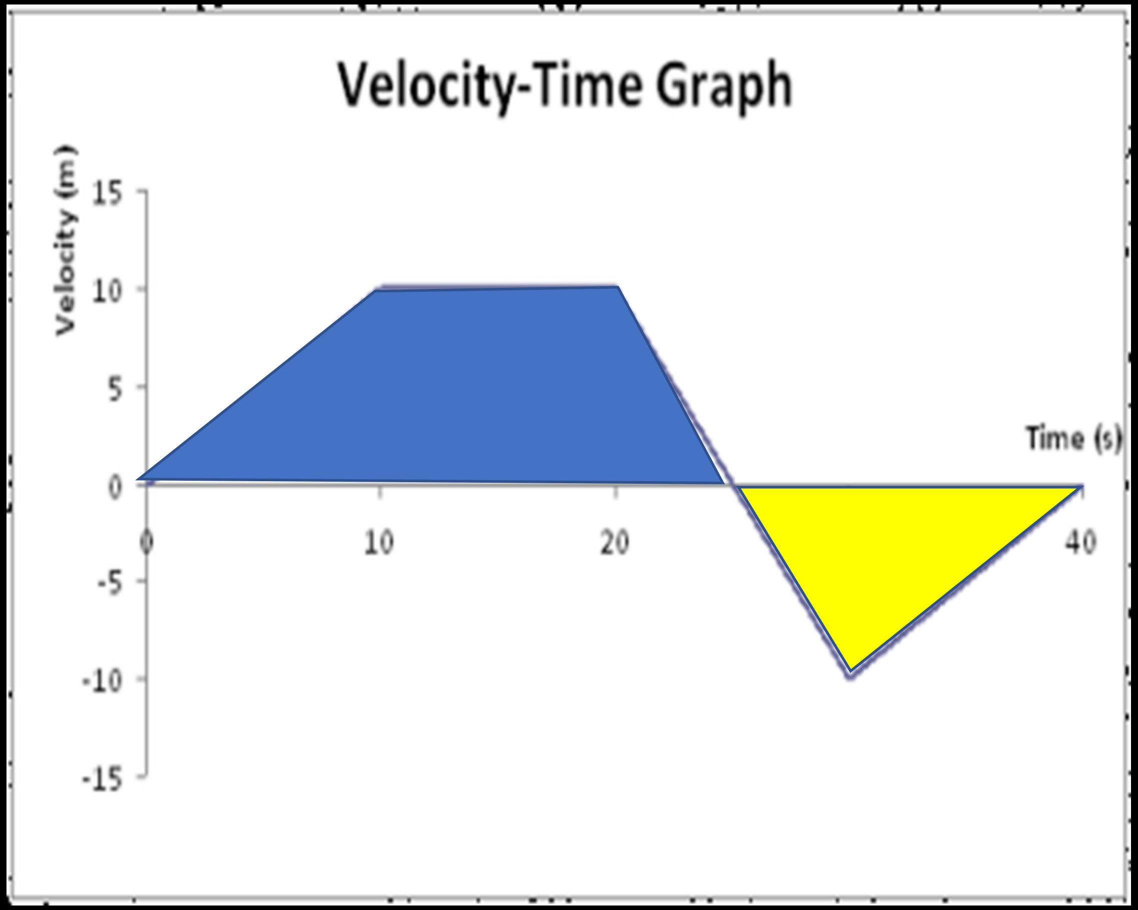


How are the following determined from velocity-time graph?

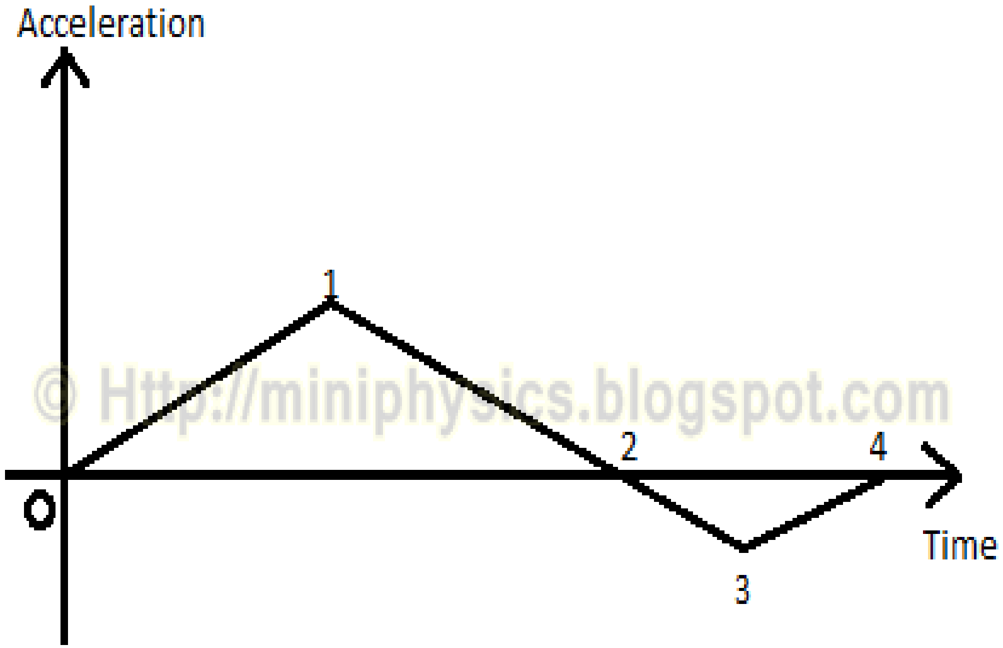
1. The acceleration of the body
2. The distance travelled
3. The displacement

20: v-t graphs review

- Acceleration = the gradient of the line
- Distance travelled = area between the line and the horizontal axis (blue + yellow)
- Displacement = (blue area) – (yellow area)

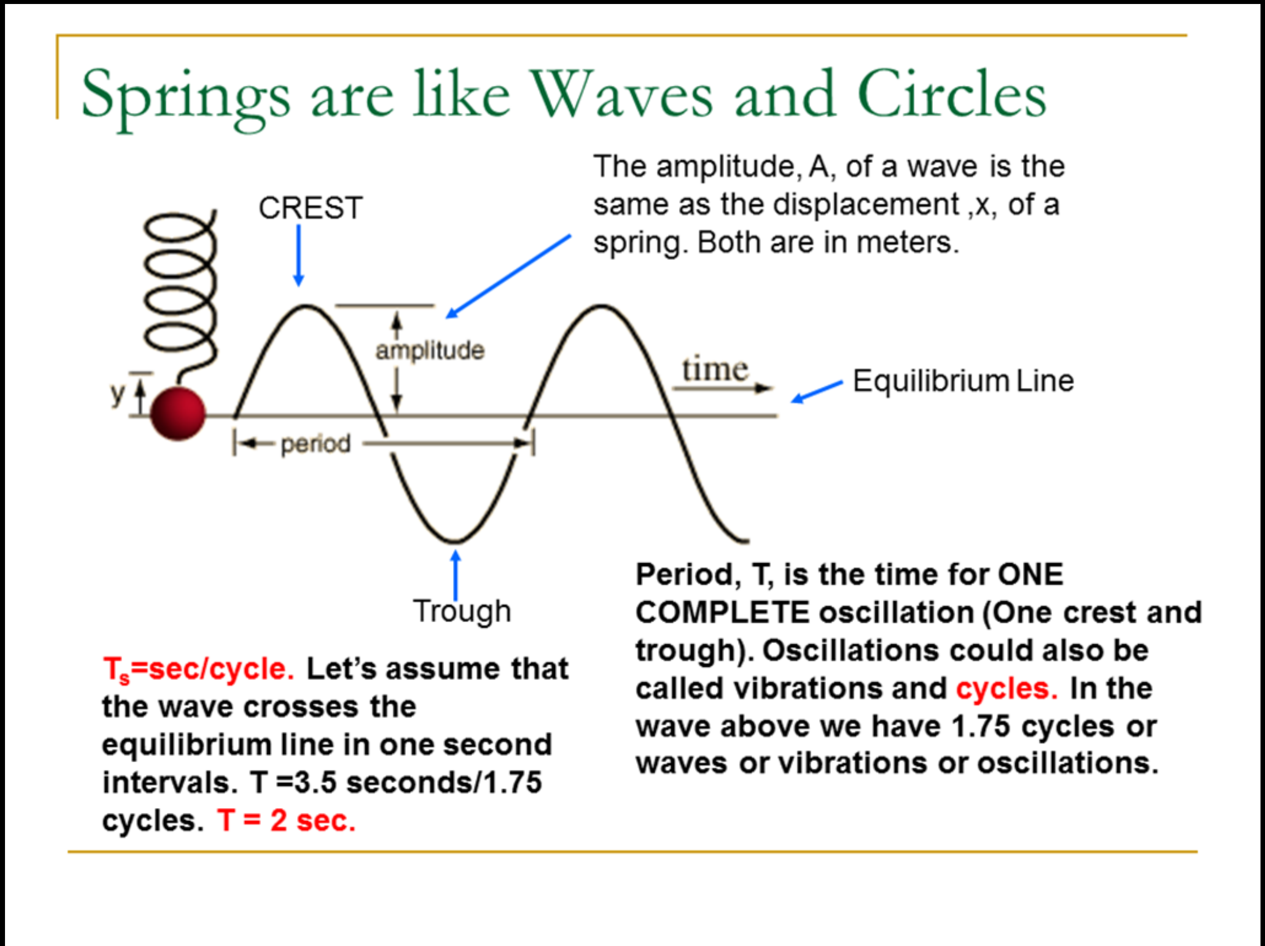


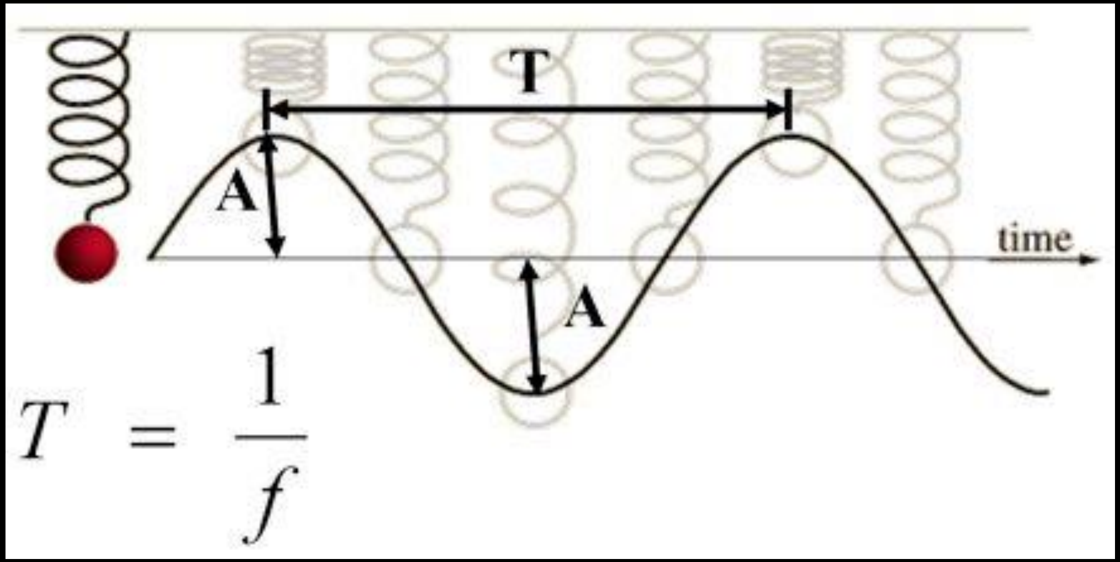
21: Acceleration-time graphs



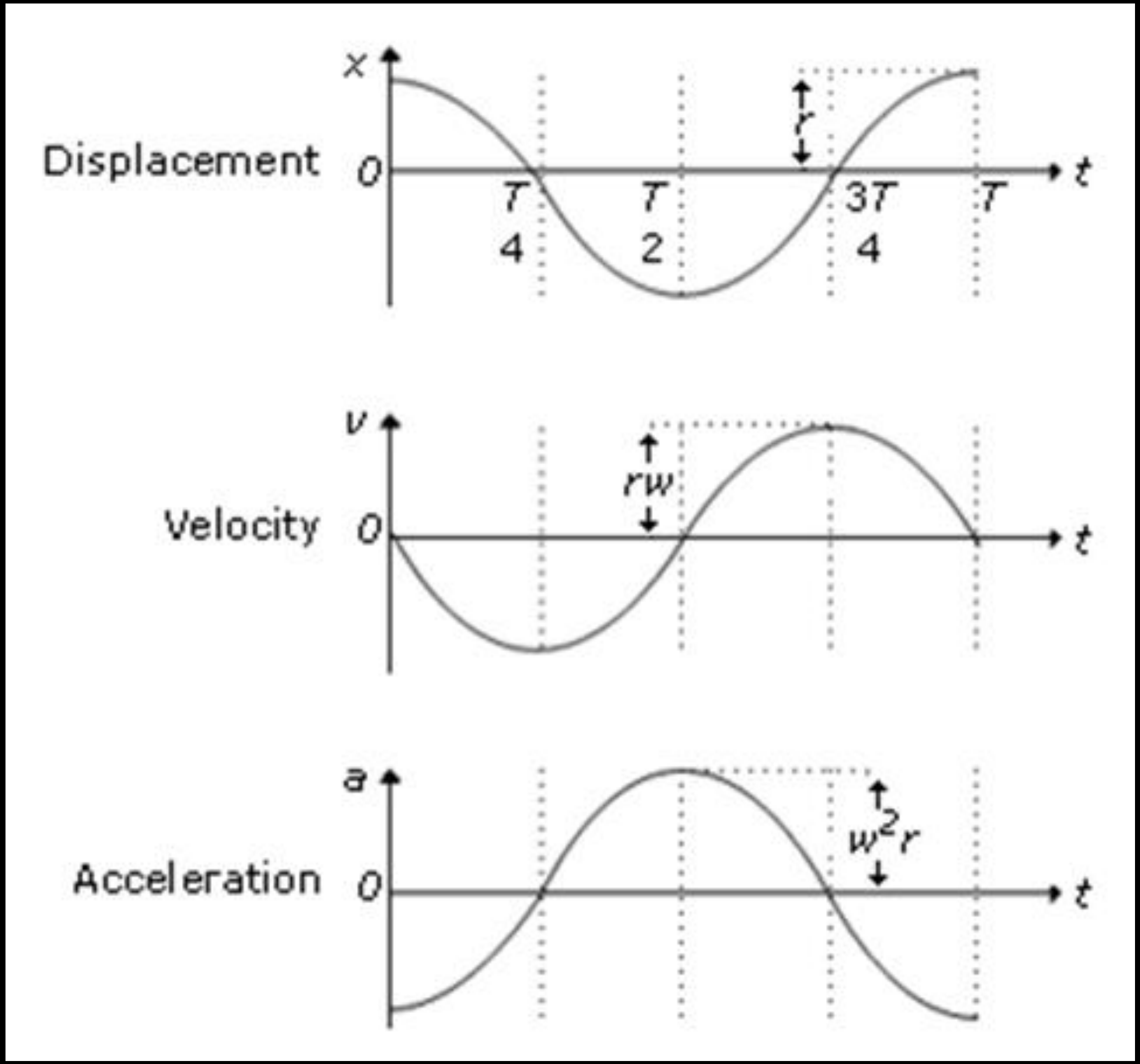
- What does this graph show?

22: Motion of a Spring





23: Motion graphs for an oscillating spring



24: Objects falling due to gravity

Investigation

WP

Finding the acceleration due to gravity by multiflash photography

Using a multiflash photography technique, or a video recording that can be played back frame by frame, we can observe the falling motion of a small object such as a marble. We need to know the time between frames.

From each image of the falling object, measure the distance it has fallen from the scale in the picture. A carefully drawn distance–time graph will show a curve as the object accelerates. From this curve, take regular measurements of the gradient by drawing tangents to the curve. These gradients show the instantaneous speed at each point on the curve.

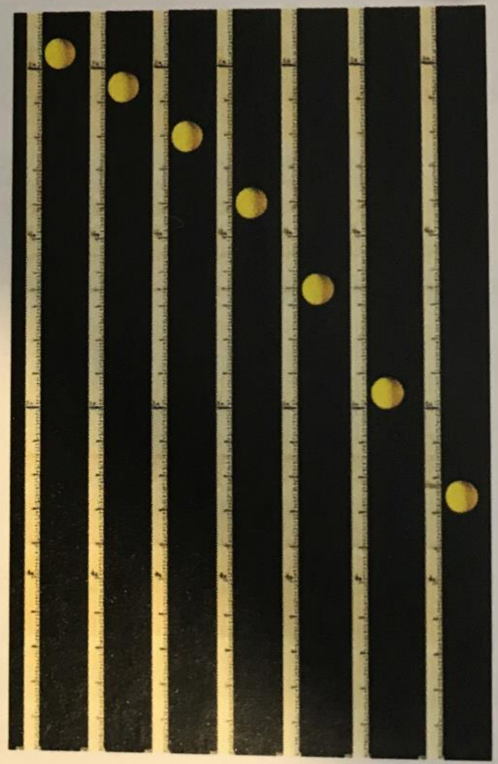
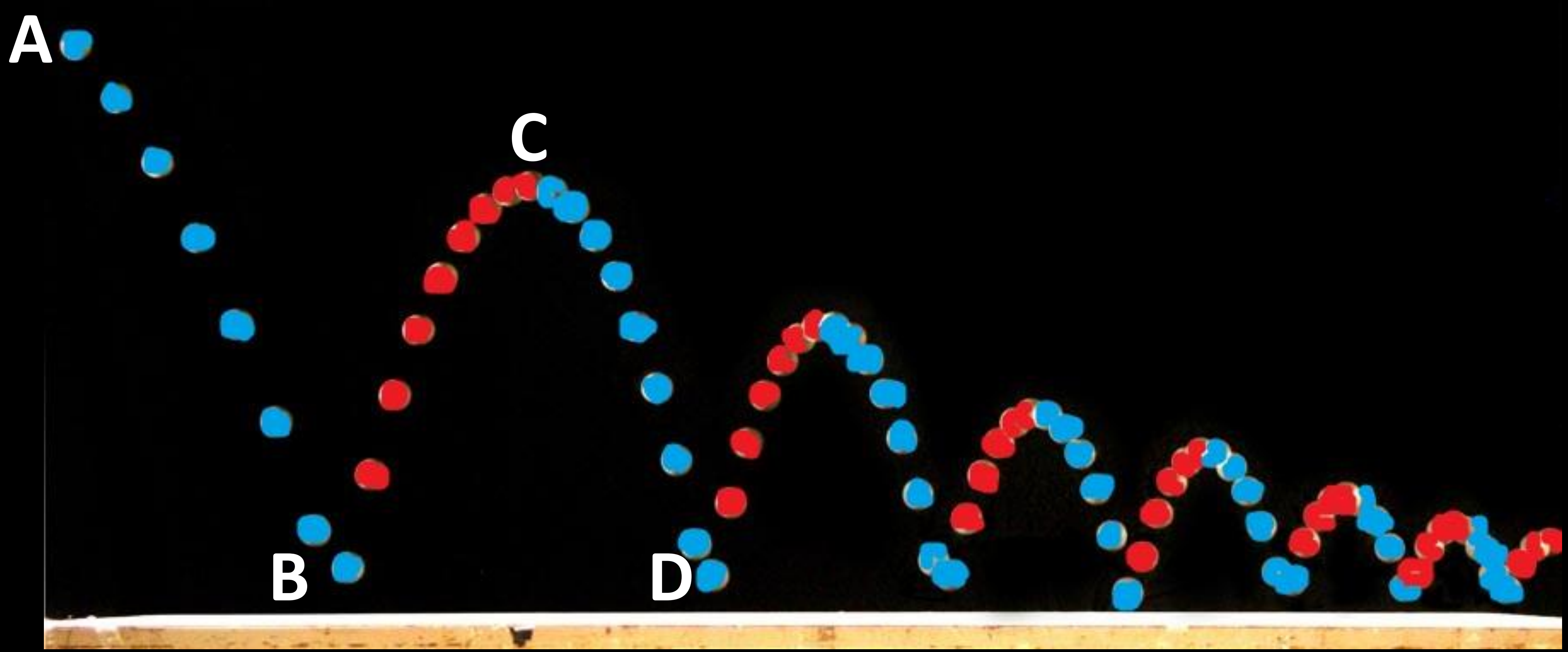
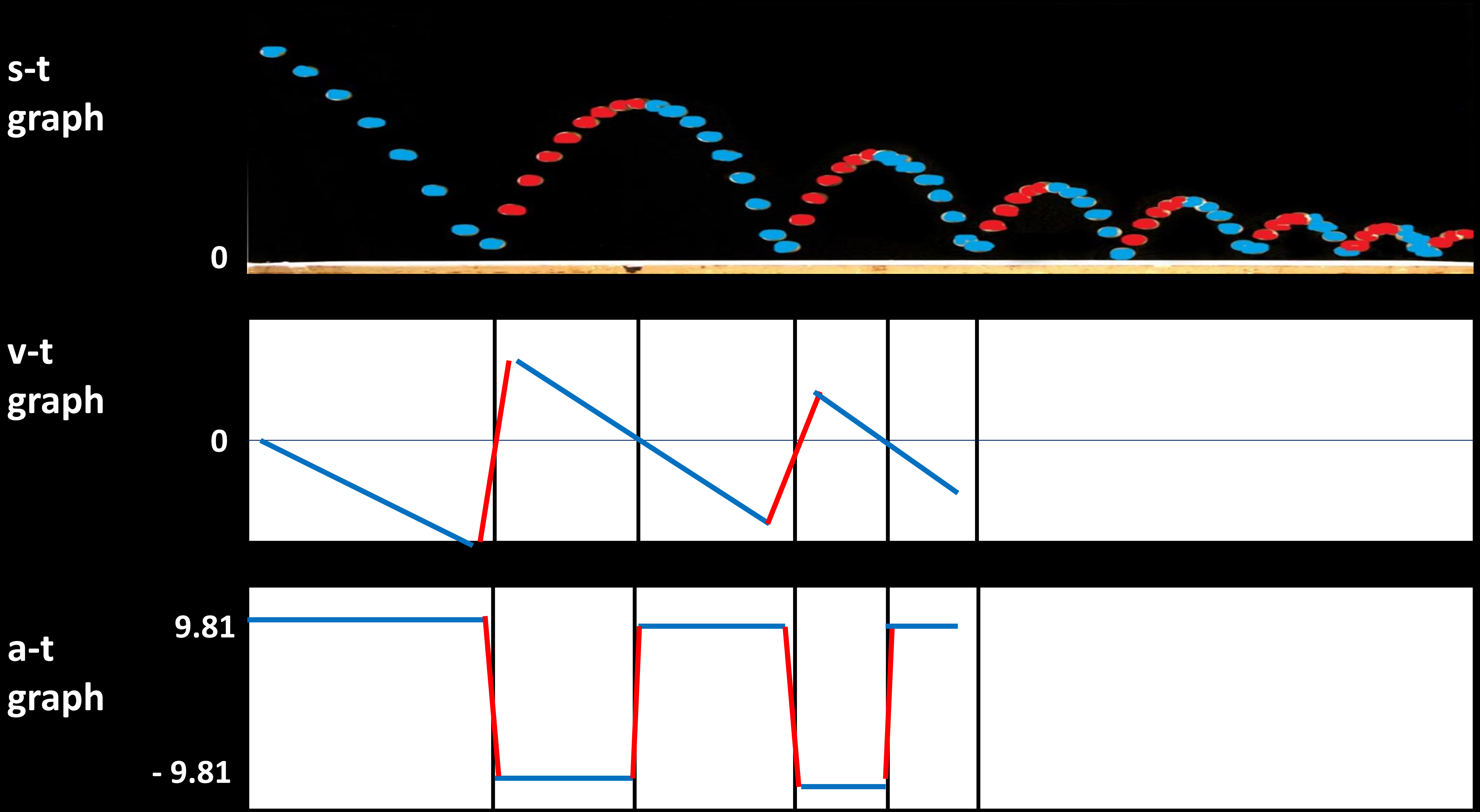


fig D Multiflash photography allows us to capture the accelerating movement of an object falling under gravity.

Plotting these speeds on a velocity–time graph should show a straight line, as the acceleration due to gravity is a constant value. The gradient of the line on this v–t graph will be the acceleration due to gravity, g.

25: Motion of a falling ball

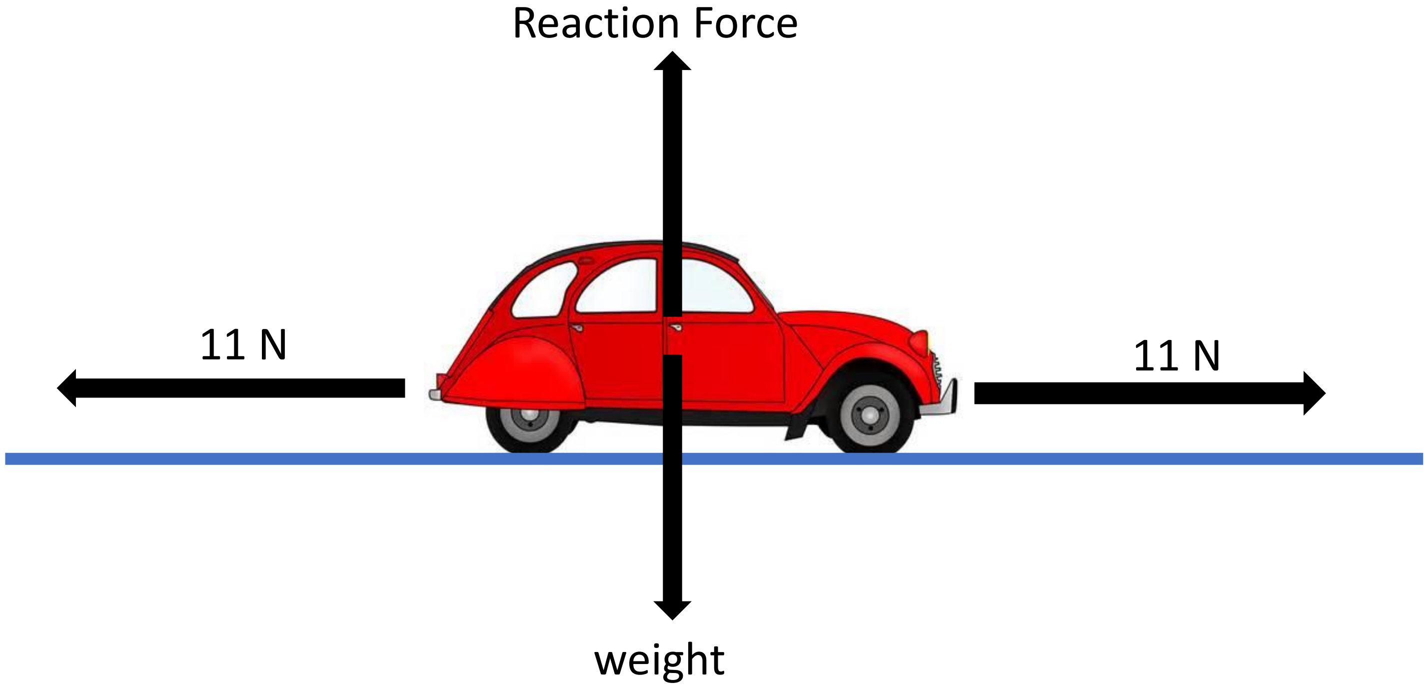



s-t graph
0
v-t graph
0
a-t graph
9.81
- 9.81

27. Newton's First Law of Motion

- If an object is stationary, it will remain stationary until a resultant force acts on it to make it move
- If an object is already moving, it will continue to move at the same speed and in the same direction (same velocity) until a resultant force acts on it. The resultant force might make the body change speed or change direction or both.
- If there is no resultant force acting, either because there are no forces acting, or all forces are balanced, the object's motion is unaffected

28. What is this car doing?



29. Newton’s Second Law of Motion

- If a resultant force acts on an object, it’s velocity will change (either in magnitude or direction, or both)

- This means that the resultant force causes a change in momentum
    - momentum = mass x velocity

- *The rate of change of momentum of an object is directly proportional to the resultant force acting on it. The change in momentum takes place in the direction of the resultant force.*

$$\text{resultant force is proportional to } \frac{\text{change in momentum}}{\text{time taken}}$$

$$F = \frac{k\,(mv - mu)}{t}$$

k is a constant of proportionality

1N is carefully defined so the k = 1

1N is the resultant force needed to cause a rate of change of momentum of $1kgms^{-1}$ each second

$$F = \frac{m(v - u)}{t} \qquad \text{OR} \qquad F = ma$$

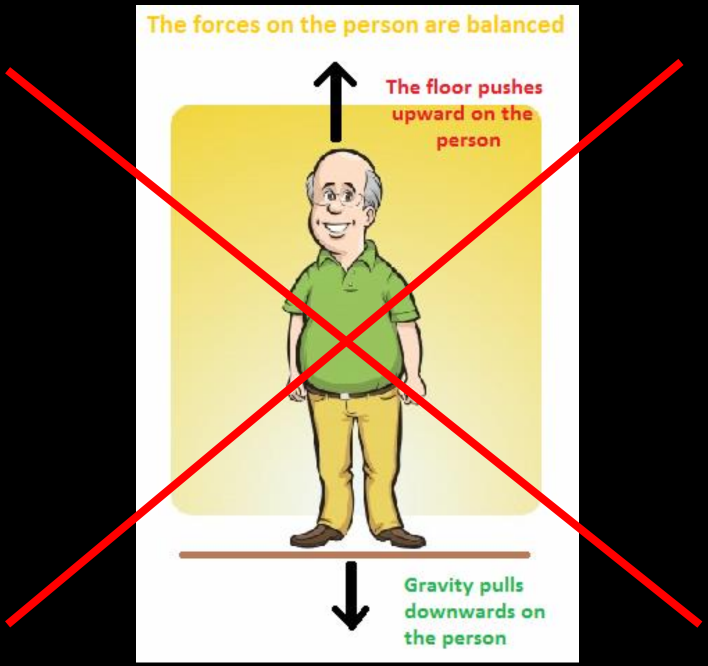
31: Newton's Third Law

- If an object A exerts a force on object B, then object B exerts an equal but opposite force on object A

- ~~For every action, there is an equal but opposite reaction~~

- Spotting Third Law pairs is not always easy

- Weight and normal reaction force are NOT third law pairs – Why?



32: Rules for Third Law pairs

Each force in the Third Law pair must:

- Have the same magnitude
- Act along the same line, but in opposite directions
- Act for the same time
- Act on a different object
- Be of the same type (e.g. 2 gravitational forces)

apply for weight and normal reaction (first three rules)

do not apply for W and R (last two rules)

- ***So what is the Third Law pair for a man standing on the ground?***

Slide 33. Post lecture tasks

- Open the **Year 11 Physics Lectures Class Notebook**.
- Go to the **Content Library** and then **Lecture 3**. You will see a page called **Mechanics Textbook Pages**. Read the information which has been copied from the A/S textbook
- In the same section, there is a page called **Follow-Up Video Clips**. Watch the 5 short videos.
- Go to your own section. **Under Post Lecture Tasks** you should see a page labelled **Tasks Lecture 3**
- Print the Q paper and write on it then then insert photos of your work into your **Tasks Lecture 3** page by **Tuesday 19 May.**