Exemplar activity 3 (age 16-18):

Unearthing SUVAT equations (Specific Teachers' Notes)

About this activity:

This is one of three exemplar activities that make up the Empowering Maths Learners collection.

This activity is aimed at learners aged 16-18.

These Specific Teachers' Notes are designed to supplement the Generic Teachers Notes that apply to all three activities and explain the rationale for the six learning phases.
You should refer to the Generic Teachers Notes alongside these Specific Teachers' Notes.
Note the diagrams/prompts below are included in a separate PowerPoint file accompanying these notes.

Additional mathematics aims specific to this activity:

This activity aims to:
- Reinforce understanding of the properties of distance-time and speed-time graphs.
- Develop understanding of time, displacement/distance, speed/velocity, acceleration and the relationship between them.
- Consolidate understanding of rearranging equations and algebraic manipulation of variables.

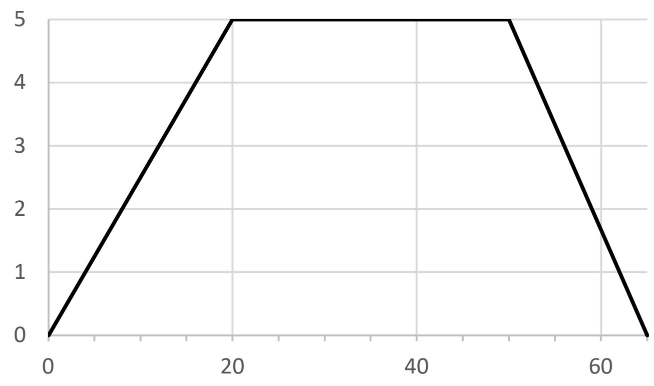
The six learning phases (refer also to Generic Teachers Notes):

Phase 1: Reviewing prior knowledge

Resources:

Students have a go at these questions, on their own to begin with, before sharing responses with others:

1. A cyclist rides in a straight line for 20 minutes. She waits for half an hour, then returns in a straight line to her starting point in 15 minutes. Here is a displacement-time graph for her journey:



   (a) Work out the average velocity for each stage of the journey in km h^{-1}.
   (b) Write down the average velocity for the whole journey.
   (c) Work out average speed for the whole journey.

2. A particle moves along a straight line. The particle accelerates uniformly from rest to a velocity of 8 ms^{-1} in T seconds. The particle then travels at a constant velocity of 8 ms^{-1} for 5T seconds. The particle then decelerates uniformly to rest in a further 40 s.
   (a) Sketch a velocity-time graph to illustrate the motion of the particle.
   (b) Given that the total displacement of the particle is 600m, find the value of T.

Additional guidance specific to this activity:

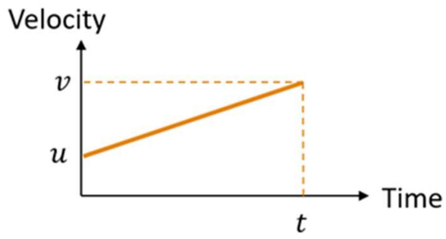
- None

Phase 2: Generating ideas

Resources:

Provide students with this prompt:

s: displacement
u: initial velocity
v: final velocity
a: acceleration
t: time



Find as many equations as possible that connect some of the variables: s, u, v, a, t.

Additional guidance specific to this activity:

- Questions to prompt discussions around prompt:
  - *What does the gradient of the line represent?*
  - *How would you work out the acceleration?*
  - *What does the area under the line represent?*
  - *How would you work out the displacement?*
- Prompts to generate questions to enable students to develop their ideas further:
  - *How would you write down a connection between some of the variables?*
  - *Which variables have we connected so far? How can we write this?*
  - *How many variables are there in each equation?*
  - *Which combinations of variables are possible? How do you know?*
  - *Can you find an equation with each of the variables (s, u, v, a, t) as the subject?*
  - *How could you go about finding all possible equations?*

Common Issues	***Suggested questions/prompts/actions***
Students struggle to recognise acceleration as gradient.	*If you had a distance-time graph, what would the gradient represent?*

Phase 3: Developing ideas

Resources:

Display the questions generated from Phase 2 so that students can work on these collaboratively in groups.

Additional guidance specific to this activity:

- Questions/prompts to facilitate group discussions/learning:
  - *How do you know if you have found all possible equations?*
  - *Can you write the equations in different ways?*

Common Issues	***Suggested questions/prompts/actions***
Students struggle to recognise acceleration as gradient.	*If you had a distance-time graph, what would the gradient represent?*

Phase 4: Formalising ideas

Resources:

You could get groups to present their ideas as posters (sugar paper, flip chart pens needed).

Additional guidance specific to this activity:

- If you are collating group's ideas without using posters, it is important you write down each equation exactly as the group has written them (include initials of all group members).
- Questions/prompts to facilitate a whole group discussion:
    - *Are any of your equations similar to those of other groups?*
    - *Are they equivalent? What is different about them?*
    - *How might a mathematician write them? Why?*

Common Issues	***Suggested questions/prompts/actions***
Equations may only differ in the choice of variable as the subject.	Emphasise that these are rearrangements of the same equations. *Which arrangement would be easiest to use for calculating [variable]?*
Students assume 'v = u + at' is correct and 'v = ta + u' is incorrect.	*Is 'v = ta + u' mathematically incorrect? Why?* *Why do you think it is 'commonly' written as 'v = u + at' in textbooks?* (avoid using 'normally' as this implies the textbook is always correct, i.e. it is the ultimate authority)

Phase 5: Reinforcing ideas

Resources:

Students have a go at a range of textbook/exam-style questions that require the application of SUVAT equations. Here are some examples:

1. A cyclist travels along a straight road. She accelerates at a constant rate from a velocity of 4 ms^{-1} to a velocity of 7.5 ms^{-1} in 40 seconds.
    (a) Find the distance she travels in these 40 seconds.
    (b) Find her acceleration in the same time period.
2. A particle is moving in a straight horizontal line with constant deceleration 4 ms-2.
   At time t=0 the particle passes through a point O with speed 13 ms-1 travelling towards a point A, where OA=20 m. Find:
    (a) the times when the particle passes through A.
    (b) the value of t when the particle returns to O.
3. A cheetah has the ability to accelerate from rest to 108 kmh^{-1} in 25 metres.
   Find the acceleration. What assumption have you made?
4. The Highway Code states that a car travelling at 20 ms^(-1) requires a minimum braking distance of 30 m. What deceleration is this and how long will it take for the car to come to rest?

Additional guidance specific to this activity:

- Questions/prompts to encourage students to reflect on their learning:
    - *How do you know which equation to use to solve the problem?*

  - *How can you use the equation to solve the problems?*
  - *Generate some hints and tips to help others solve similar problems.*

Phase 6: Deepening understanding

Resources:

Pieces of card (A5 or A6 – different colours?) for students to devise and share questions with each other (see Generic Teachers Notes).

Additional guidance specific to this activity:

- None