

# WELCOME!

Welcome to the first of our physics tutorials, designed for sixth form students who may be interested in a physical sciences degree. Throughout the programme, you will be challenged in a number of different ways, each of which should help you understand some relevant physics - but more importantly, to think as a physicist. Most of the tasks will support your A-level studies in some way, but they may also explore ideas from degree studies, cutting edge research and real-world applications.

## GROUND RULES

- 1 You will need to attempt the home learning before the tutorial for the course to be effective.
- 2 Try to find a quiet space where you will not be interrupted, and spend at least 30 minutes on these problems. They could take up to an hour.
- 3 We do not expect you to always be able to answer every question in the home-learning, or during the tutorial. Being a good physicist is not about being able to answer everything straight away! We do want you to think about why you are getting stuck, and which questions you need to ask to help you develop your physics skills.
- 4 We would like you to attempt every question and record all your working and assumptions, even if you do not get a final answer.
- 5 Please arrive on time to the tutorials (aim to be a couple of minutes early if possible) and have the following materials with you:
  - answers electronically or written down
  - pen and paper
  - a scientific calculator



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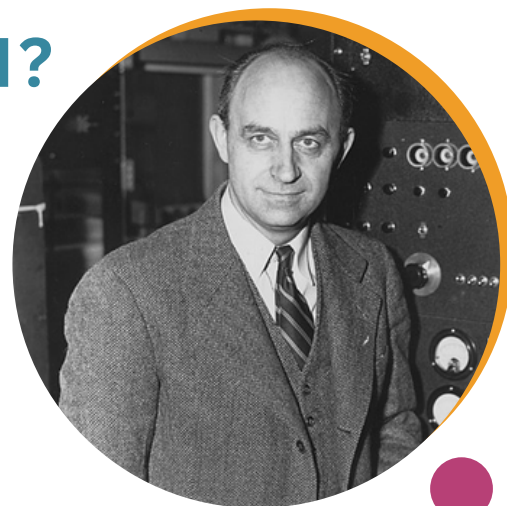
## PRE-TUTORIAL MATERIAL SESSION 1: THINKING LIKE A PHYSICIST

Your first tutorial is all about thinking like a physicist to solve problems. The aim of this pre-session content is to get you to use what you know to estimate the answer to complex problems.

### WHAT IS A FERMI PROBLEM?

Enrico Fermi was an Italian-born Nobel Prize-winning scientist who created the world's first nuclear reactor, and also worked on statistical mechanics, quantum theory and particle physics. During the Second World War he worked on the Manhattan project in the USA; as part of the project he was a part of the team that created the world's first atomic bombs. He led an eventful life, becoming an immigrant in and then a citizen of the USA to escape the rise of fascism in his home country with his Jewish wife.

Fermi was well-known for making rough 'back of the envelope' calculations where he would quickly work out an approximate answer to something, that was accurate to within an order of magnitude. Because of this, Fermi's name is used to describe a type of question that can be answered in this way. By breaking down a large unknown problem into a series of smaller steps, combined with sensible use of estimation, this approach enables us to figure out something of interest without having to spend a huge amount of time finding out the exact numbers needed for an accurate calculation.



*These types of problems are called Fermi problems!*



### TASK 1: FERMI PROBLEM EXAMPLE

Watch author and ex-NASA scientist Randall Munroe talk about Fermi problems in this video:

**10 MINS**

<https://www.youtube.com/watch?v=l64CQp6zOPk>



### TASK 2: TRY A FERMI PROBLEM

30 MINS

Now try a Fermi problem for yourself. Choose **one** of the questions below and estimate an answer to it. But remember, no cheating: you are not allowed to look anything up!

**1** How many Shreddies has the average 17-year-old eaten?

**a** List any assumptions you have made.  
*e.g. sizes of things, how often something happens, etc.*

**b** Estimate the level of confidence you have in each assumption.



**2** How many £1 coins can you fit in an average backpack?

**a** List any assumptions you have made.  
*e.g. sizes of things, how often something happens, etc.*

**b** Estimate the level of confidence you have in each assumption.

OR

### TASK 3: LINKING TO PHYSICS

5 MINS

It's quite possible to get through life without needing to know how many Shreddies a 17-year-old has eaten, or how many pound coins you can fit in a backpack. However, the **skills** you need to answer these sorts of questions can be very useful to any scientist.

**What skills are you practising when you are solving Fermi questions that will help you as a scientist?**

### TASK 4: PERSON PROFILE

10 MINS

Watch Jane Greaves, a physicist at Cardiff University, explain the discovery of phosphine on Venus and what it might mean:

She is very careful with her words – she accurately describes the observations she has made and what they demonstrate, but is careful not to make any assertions about what they might mean.


<https://www.youtube.com/watch?v=5llj3e5BFp0>



### OPTIONAL EXTRAS

Fermi problems will be used several times throughout these tutorials. If you really enjoyed them, or want to get better at them, then you can find many more questions (and solutions) in the following resources:

Guesstimation: Solving the World's Problems on the Back of a Cocktail Napkin  
Lawrence Weinstein



More about Fermi's life and the world's first nuclear reactors:  
<https://interestingengineering.com/culture/enrico-fermi-the-man-who-gave-the-world-nuclear-fission>

Some Fermi problems (and solutions) on the University of Maryland website:

<http://www.physics.umd.edu/perg/fermi/fermi.htm>

Serious answers to absurd questions and absurd advice for common concerns, from Randall Munroe (Task 1):

<https://what-if.xkcd.com/archive/>

