A Level Mathematics

Chapter 8 - Mechanics

Modelling in Mechanics

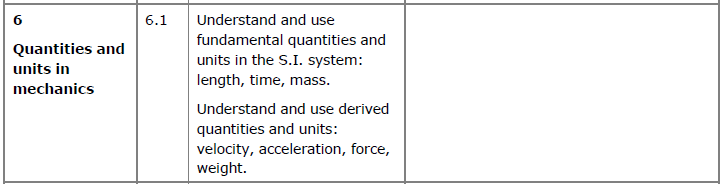
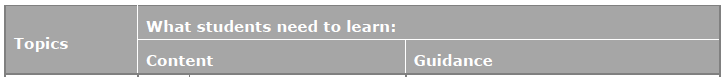
Chapter Overview

1. Constructing a Model

2. Modelling Assumptions

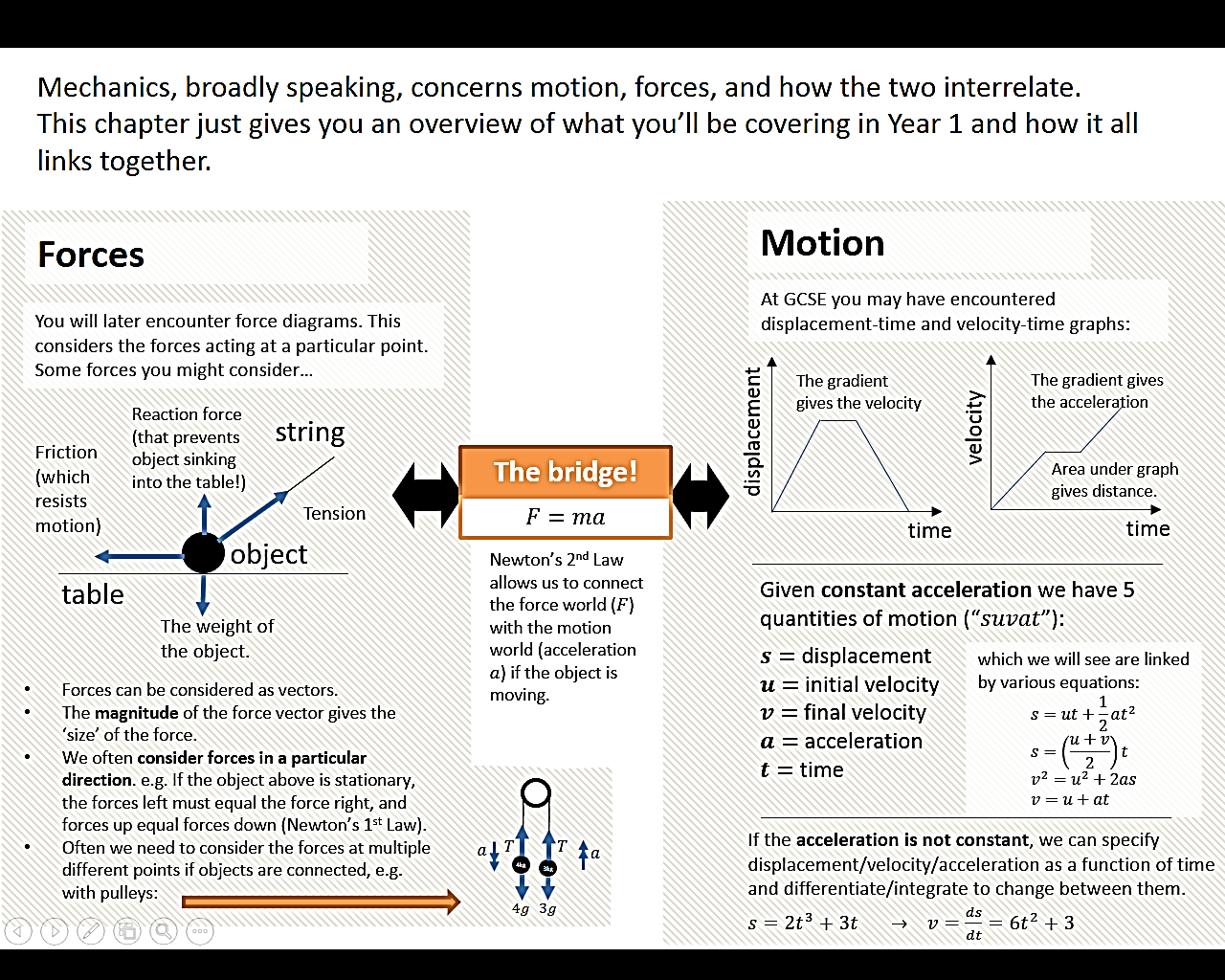
3. Quantities and Units

4. Working with Vectors



**What is Mechanics?**

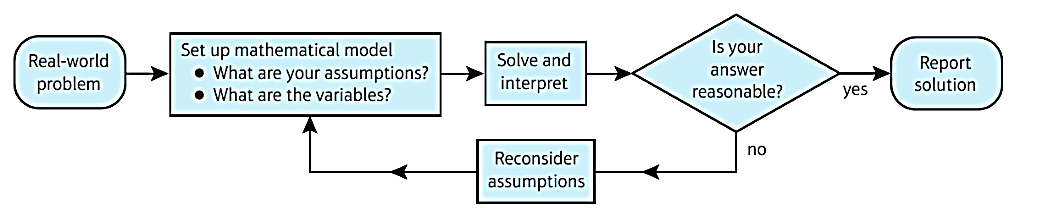
Broadly speaking, mechanics covers motion, forces and how the two inter-relate with each other.



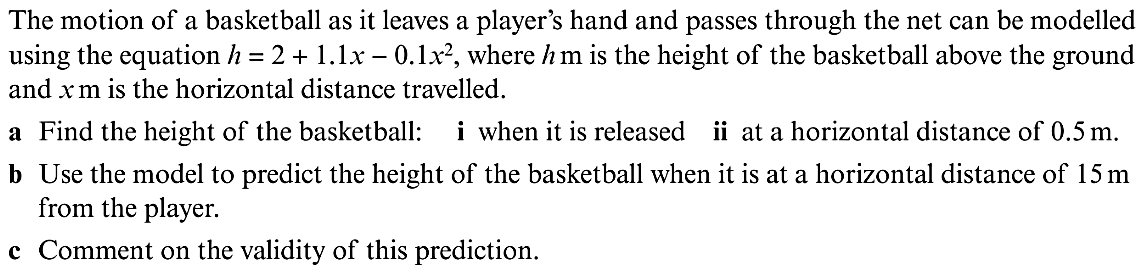
1. **Constructing a Model**

Why use a mathematical model?

The solution to a mathematical model needs to be interpreted in the context of the original problem. You may need to refine the model and reconsider your original assumptions.



**Example** *(Textbook)*

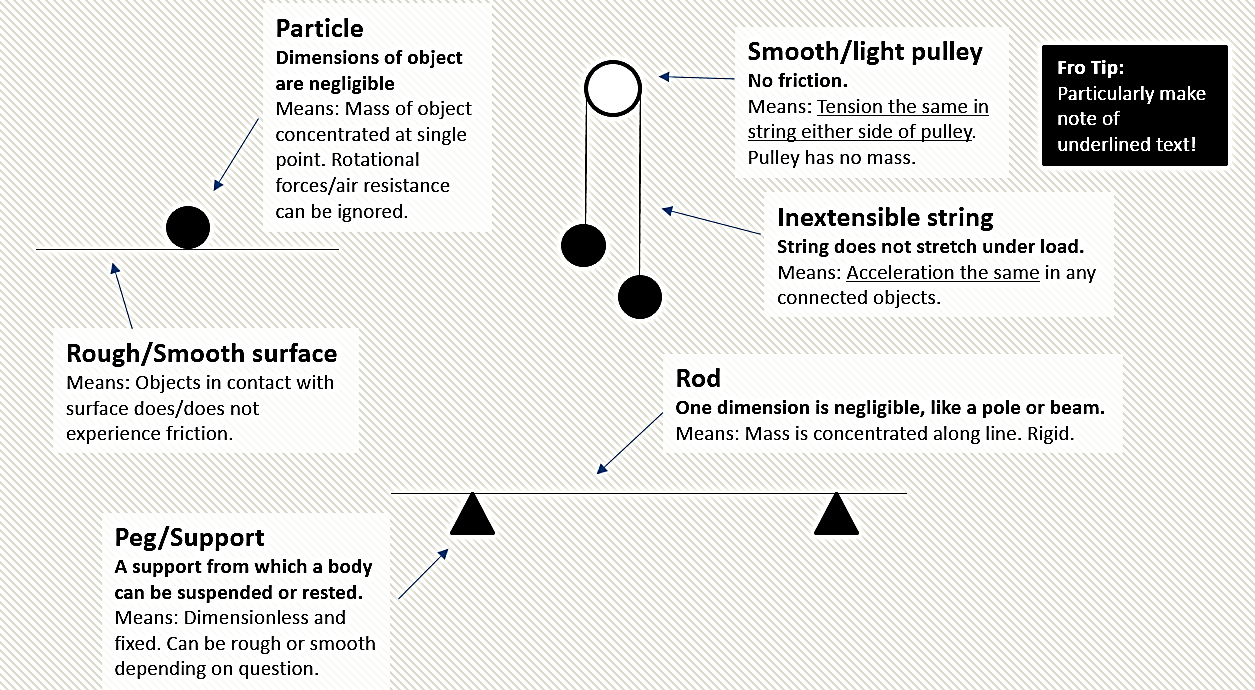


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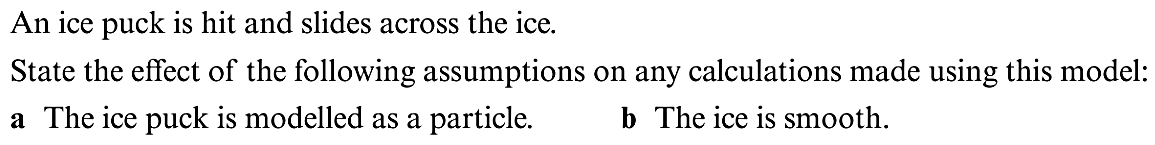
1. **Modelling Assumptions**

We make modelling assumptions to simplify a problem and solve it using known mathematical techniques. You must be able to understand how these assumptions will affect calculations versus the real-life situation.

A full list of modelling assumptions is on p121 of the textbook. The most common are shown below.



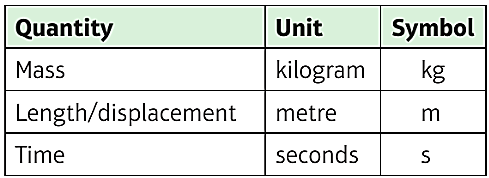
**Example** *(Exercise 8B Question 2)*



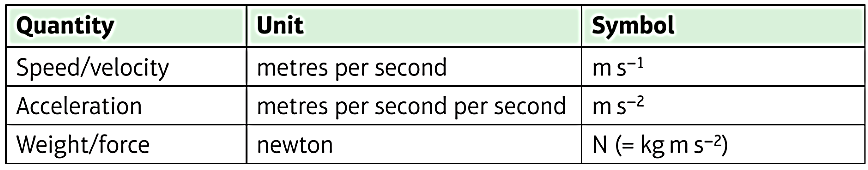
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1. **Quantities and Units**

The SI units are a standard system of units, used internationally (“Système International d’unités”). These are the **base** ones you will use:



These **derived** units are compound units built from the base units.



Can you convert 2.48 x 105 kmh-1 into SI units?

**Types of Force and Force Diagrams**

You will encounter a variety of forces in mechanics. It is ALWAYS helpful to draw a force diagram and make sure that you have included all forces acting on a body.

* Weight (always vertically downwards)
* Normal Reaction (always perpendicular to the surface of contact)
* Friction (only if the plane is ROUGH, always opposes motion)
* Tension (in a string – PULL force)
* Thrust/compression (e.g. in a rod or engine – PUSH force)
* Resistance (e.g. particle travelling through a liquid, always opposes direction of motion)
* Buoyancy (e.g. boat floating in water, always vertically upwards)

Force diagrams can be found on page 123 of the textbook.

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1. **Working with Vectors**

In Mechanics you will often need to convert to/from the scalar form of a quantity and the vector form.

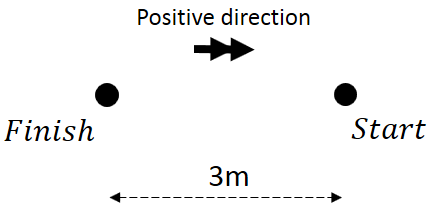
**SCALAR:**

**VECTOR:**

Examples of scalars and vectors:

|  |  |
| --- | --- |
| **Scalar** | **Vector** |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

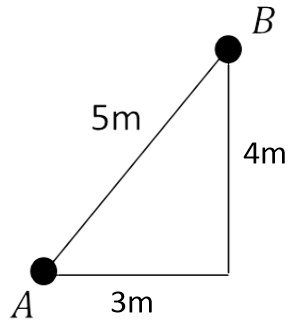
NB: 1-dimensional vectors are still different from scalars. Consider the displacement on a 1-dimensional line in a particular direction. If we’d gone backwards 3 units…



What is the distance travelled?

What is the displacement of the particle?

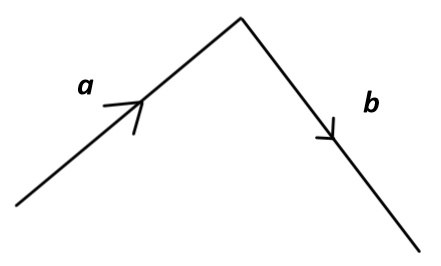
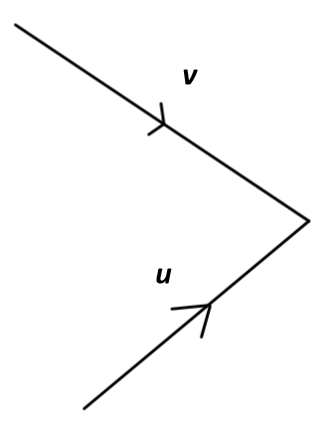
**Vector Notation**



**Column Notation *i*-*j* Notation**

(***i*** and ***j*** are **unit** vectors of length 1)

**Adding and Subtracting Vectors**

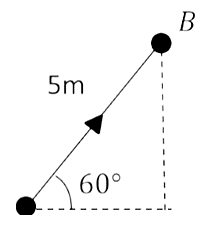
Two vectors are equal if they have the **same magnitude and direction**.

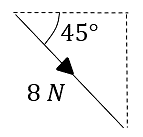
Two vectors are parallel if they have the **same direction but different magnitudes.**

**Converting Between Vectors and Scalars**

To convert to vector form, just use basic trigonometry to find the *𝑥* -change and *𝑦* -change.

**Scalar (Distance) Vector (Displacement)**

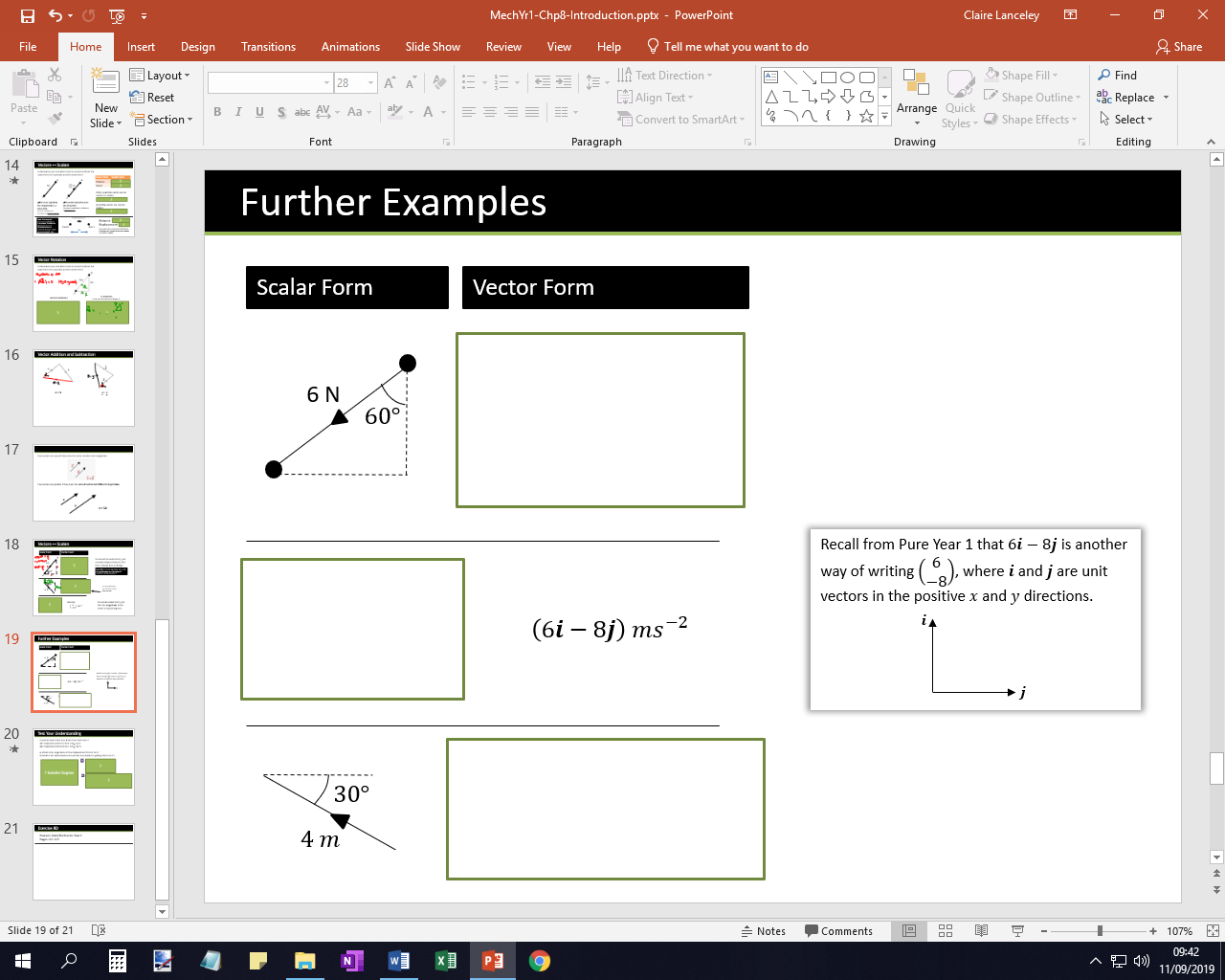




To convert scalar form, just find the **magnitude** of the vector using Pythagoras.

**Vector (Velocity) Scalar (Speed)**

**Further Examples**



**Test Your Understanding**

A woman walks from A to B and then from B to C.

Her displacement from A to B is 6i + 4j m.

Her displacement from B to C is 5i - 12j m.

a) What is the magnitude of the displacement from A to C?

b) What is the total distance the woman has walked in getting from A to C?

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Mixed Exercise 8 Page 128