	Y13 Applied	CH04 4.1,4.2,4.3,4.4,4.5	Mechanics Moments	Lessons 4

Essential Knowledge Milestones

- realise that a force can produce a turning effect;
- know that a moment of a force is given by the formula force × distance giving Nm and know what the sense of a moment is;
- understand that the force and distance must be perpendicular to one another;
- be able to draw mathematical models to represent horizontal rod problems;
- realise what conditions are needed for a system to remain in equilibrium;
- be able to solve problems when a bar is on the point of tilting.

Success Criteria

- ❑ You can calculate the turning effect of a force applied to a rigid body
- ❑ You can calculate the resultant moment of a set of forces acting on a rigid body
- ❑ You can solve problems involving uniform rods in equilibrium
- ❑ You can solve problems involving non uniform rods
- ❑ You can solve problems when a bar is on the point of tilting.

Teaching Points

- Start by asking two students to push up and down equally on two points of a ruler (or rod/beam) which are directly above or below each other. The forces balance and if we resolve vertically, the resultant force is zero. Hence the ruler will not move (equilibrium). However, if the two positions are separated, the ruler will turn, despite the forces still having no resultant in the vertical direction. So if two (or more) forces are not concurrent, there may be a turning effect. (See diagrams below.)

- Next think about a door handle and imagine it was moved nearer the hinge of the door. Common sense tells us the door will be harder to open or close, so any formula for the turning effect of forces must involve distance as well as force.
- Show a bicycle pedal in different positions and discuss which one makes turning easier. (See diagrams below.)

- A discussion around this can lead to the understanding that the moment of a force, is a measure of its turning effect and is given by the formula:
- moment of a force about a point = force (*F*) × perpendicular distance from the point to the line of action of the force (*d*) (the unit is newton metres, N m)
- Ask students questions such as: How do we work out the distance, *d*, in the second bicycle pedal diagram? What additional information do we need? What if the pedal was at the topmost point, vertically above the axle?

Teaching Points

- The force and distance must be perpendicular to one another, but in this unit we will only be considering horizontal bars, supported or suspended by reactions and tensions respectively. These forces will naturally be vertical and parallel to one another, so the moments formula can be applied easily and the only thing to consider is the *sense* of the moment (whether the turning effect of each force is clockwise (negative) or anticlockwise (positive)).
- Demonstrate that a uniform ruler will balance about its centre (where all the weight acts) and that this central point is therefore its centre of mass. Use this to extend students' basic idea of equilibrium as a system where there is no resultant force and also no overall turning effect, i.e. R(↑) = 0 N and the sum of the moments = 0 N m.
- Make sure all the assumptions are revisited from earlier in the course e.g. model a rod as a straight line, a person standing on a bridge as a particle, strings being inextensible etc. The centre of mass is at the centre of the rod only if it is stated as being uniform.

- Before starting on questions, make sure students know the notation: when we 'take moments' about a certain point (say A), we write this as M(A). Cover questions that involve:
  - rods resting on two or more supports
  - a rod which is suspended at two or more points
  - finding the position of the centre of mass of a non-uniform rod.

- Make sure you stress that theoretically we can take moments about any point and, together with resolving (vertically), we can solve any problem. However, some positions will make the solution more efficient and subsequently involve less algebra. Show students that taking moments about a point through which a force acts is zero as the distance to that force is zero.

Assumed Prior Knowledge/ Links / Interleaving	Opportunities for Reasoning/Problem Solving/Proofs
GCSE (9-1) in Mathematics at Higher Tier • Solving linear and simultaneous equations AS Mathematics – Mechanics • Basic equilibrium	• Tilting Problems: consider rods on the point of tilting. (You could demonstrate with a ruler resting on a couple of erasers, then add some coins to the end until it lifts off one of the supports.)The forces still remain vertical and the rod horizontal (just) as the rod tends to want to lift. One of the reaction 'becomes' zero at the point of tilting. **Potential Barriers to Access /Misconceptions** • Many students made their life more difficult than necessary by not taking the easy resolving option and using two moments equations resulting in simultaneous equations which can be difficult to solve. • Clear diagrams can help to overcome some errors such as using distances from the wrong point or missing forces (often the weight). • Students should also be reminded to read the question carefully and give their answer in the correct form – being particularly careful not to mix up weight and mass.

Key Mathematical Vocabulary	Moment, turning effect, sense, newton metre (N m), equilibrium, reaction, tension, rod, uniform, non-uniform, centre of mass, resolve, tilting, 'on the point', concurrent.

Personal Development	Notes	Resources
Independent work that requires a planned approach in terms of time management and self-discipline in order to meet deadlines within exam conditions.		