5.2 Stability, rotation and projectiles

Name: _____ Class: _____ Date: _____ **Total: 30 marks**

KEY WORDS centre of mass • base of support • torque • moment of inertia • angular momentum • projectile

Objective

Build the skills to answer exam questions on **stability** , **torque** , **angular momentum** and **projectile motion** , and on analysing a skill in phases.

You must be able to:

- explain how the centre of mass, base of support and line of gravity affect stability
- calculate torque and explain the conservation of angular momentum
- explain the factors that affect the flight of a projectile
- resolve a release velocity and explain the sequencing of body segments

1 Key knowledge and worked examples

■ Stability, rotation and projectiles

The **centre of mass** (COM) is the point where the body's mass can be thought to act. In a standing person it is about at hip level; it moves when limbs move and can lie outside the body (a high-jumper's arch).

Stability is greater with: a **wide base of support**; a **low** COM; the **line of gravity** near the centre of the base; a large mass. Sprinters in the set position have low stability, so they can move quickly.

Torque (moment) = force × perpendicular distance from the axis (N m).

Angular motion: angular momentum $L = I\omega$ (moment of inertia × angular velocity). In the air, L stays constant (it is **conserved**). Tucking reduces I, so ω rises (faster spin); opening out increases I and slows the spin, ready for entry or landing.

Projectiles: the horizontal distance depends on **release speed** (most important), **release angle** and **release height**, plus air resistance and spin. If release and landing heights are equal and air resistance is ignored, 45° gives the longest distance. If the release point is **above** the landing point (shot put), the best angle is **less** than 45°. Athletes also produce more speed at lower angles.

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Analysing a skill: split it into **phases**: preparation, execution (action) and recovery (follow-through). Fast throws and kicks use a **proximal-to-distal sequence**: large, central segments start first; each segment adds speed to the next (kinetic chain).

AHL – components: a release velocity v at angle θ has horizontal part $v\cos\theta$ and vertical part $v\sin\theta$; time to the top is $v\sin\theta \div g$.

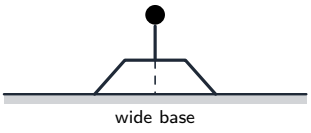
Answer shapes: name the factor, say how it changes the outcome, and give the mechanical reason.

2 Practice

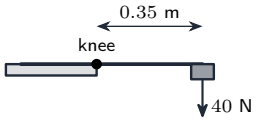
2.1 Define centre of mass, and state where it is for a person standing upright. [2]



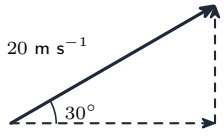
2.2 Explain **three** ways a wrestler can make himself more stable. [3]



2.3 A 40 N ankle weight is 0.35 m from the knee joint, acting at right angles to the shin. Calculate the torque about the knee, and state the torque if the perpendicular distance halves. [3]



2.4 A ball is kicked at 20 m s^{-1} at 30° above the horizontal. Calculate the horizontal and vertical components of the velocity, and the time to reach the highest point. [3]



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3 Exam-style questions

3.1 A diver leaves the board, tucks tightly, then opens out before entering the water.

(a) Explain, using angular momentum, why the diver spins faster in the tuck. [3]



(b) State what happens to the rate of spin when the diver opens out. [1]

3.2 A shot-putter releases the shot about 2 m above the ground.

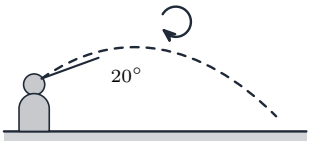
(a) State **three** factors that affect the horizontal distance of the throw. [3]



(b) Explain why the best release angle for the shot put is less than 45°. [3]

3.3 A long jumper takes off at about 20°.

(a) Explain why the take-off angle is much lower than 45°. [2]



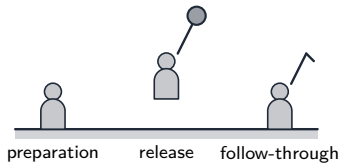
(b) Explain why the jumper "cycles" the arms and legs in the air. [2]

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3.4 A basketball player performs a jump shot.

(a) Identify the **three** phases of the skill. [2]

(b) Explain how the sequence of segment movements helps produce a fast, accurate release. [3]



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