Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

the point where the mass of the body can be considered to be concentrated / where gravity acts; about hip level, behind the navel

2.2

widen his base of support, e.g. feet further apart; lower his centre of mass by bending the knees; keep his line of gravity near the centre of the base, so a push must move it further to topple him

2.3

torque $= 40 \times 0.35 =$ **14** N m; halved distance: **7** N m

2.4

horizontal $= 20\cos 30^\circ \approx$ **17.3** m s^{-1}, vertical $= 20\sin 30^\circ =$ **10** m s^{-1}; time $= 10 \div 9.81 \approx$ **1.0** s

3.1

(a) angular momentum ($L = I\omega$) is constant in the air; tucking brings mass closer to the axis, so moment of inertia falls; so angular velocity must rise

(b) it slows down

3.2

(a) release speed; release angle; release height (also air resistance)

(b) the shot is released above the landing height; so it lands later and further at a lower angle; 45° is best only when release and landing heights are the same; also the athlete can produce more release speed at lower angles, because the muscles push more horizontally

3.3

(a) the jumper arrives at high horizontal speed and has only a short contact time; a steeper take-off would need a large loss of horizontal speed, which matters more for distance

(b) take-off gives the body forward angular momentum, which would rotate it forward; rotating the arms and legs forward takes up this angular momentum, so the trunk stays upright for a good landing

3.4

(a) preparation, execution (release), recovery (follow-through); all three for [2], two for [1]

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(b) movement starts in large, proximal segments (legs, trunk) and moves to small, distal ones (upper arm, forearm, wrist); each segment starts as the previous one reaches its peak speed, so speed is added along the chain; the final wrist flick controls direction and backspin, giving accuracy