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Answers

Exam-style questions

Anna Snook and Adam Morton

Check your answers to the questions in this issue.

Biomechanical principles: angular motion and momentum (pp. 9–11)

- 1 Changing the shape of the body causes a change in speed. The ice skater changes their moment of inertia to cause a change in speed or velocity of rotation about the axis. Angular momentum is the quantity of rotation and remains constant during the rotation.

Angular momentum = angular velocity (speed of rotation) $\times$ moment of inertia (distribution of mass away from the longitudinal axis)

So, to speed up the rotation (increase the angular velocity), the skater must decrease their moment of inertia, which they achieve by tucking their arms in, closer to the longitudinal axis that runs vertically through the body. This will result in multiple, fast spins and score them higher marks in competition. To exit the spin, the performer must slow down, which involves increasing the moment of inertia. They do this by opening out their arms. This slower speed also allows them to make a more stable landing on the ice. As a final point, the ice is a relatively friction-free surface.

- 2 Newton's first law of angular motion states that a body will continue to turn about its axis of rotation (with constant angular momentum), unless a force is exerted upon it. This means that the gymnast will continue to spin or rotate continuously, or with constant angular momentum, unless a force acts upon them. This is known as the principle of conservation of angular momentum.

To change their rate of spin, the gymnast must change their body position. Newton's second law of angular motion states that the more (rotational) force the gymnast applies to the take-off (also known as torque), the more powerful the take-off and so the higher they will jump. This means that they can execute more rotations before landing, which will yield a higher mark in competition.

If the gymnast trains their fast-twitch glycolytic muscle fibres (type IIx), such as via strength, power or plyometric training, they will be able to jump higher, maximising their time in the air for rotations. Newton's third law of angular motion states that when they take off, they will apply a rotational force to the ground and the ground responds by generating a rotational force in the opposite direction, assisting their rotation. Equally, when the gymnast lands, they apply a rotational force to the ground to slow themselves down and the ground applies a rotational force in response.

3 AO1

Angular momentum (the quantity of rotation) = angular velocity (speed of rotation) × moment of inertia (distribution of mass away from the longitudinal axis)

Angular momentum remains constant during the rotation, known as the conservation of angular momentum.

AO2

Angular momentum is conserved unless an external torque acts upon the performer. If the performer requires a change of speed of rotation, they must change the shape of their body. To do this, they must change their arm/leg position in relation to the axis they are rotating about. To conserve angular momentum, if moment of inertia increases, then angular velocity decreases. Equally, if moment of inertia decreases, then angular velocity increases.

To speed up (increase angular velocity), the performer decreases their moment of inertia, which they achieve by tucking/bringing their arms/legs in towards the axis of rotation. To slow down, the dancer does the opposite, increasing their moment of inertia in order to decrease angular velocity, by opening out their arms.

AO3

The dancer will aim to increase their speed of rotation when taking off from the ground and entering the rotation. When landing, they will aim to slow down. Newton's third law of angular motion states that when they take off, they will apply a rotational force to the ground and the ground responds by generating a rotational force in the opposite direction, assisting their rotation. Equally, when the dancer lands, they apply a rotational force to the ground to slow them down and the ground applies a rotational force in response.

Training fast-twitch glycolytic muscle fibre types will result in increased jump height. Plyometric training would also be valuable for this. Multiple repetitive jumps and landing could increase the risk of injury, so the dancer should plan their training year (periodisation) well in order to help prevent injury. They could also use taping and bracing and adapt their diet and nutrition to recover well, prior to subsequent training sessions. The performer could use the principle of impulse when landing to spread force for longer and make landings safer.

The sports science behind the 400 m race (pp. 30–33)

- 1 Speed = distance / time
= 400m / 56s
= 14m/s
- 2 Force = mass × acceleration
Acceleration = force / mass
= 350N / 76kg
= 4.6m/s²

- 3** A duration of 60 seconds and high intensity means that the glycolytic system is the main energy provider.
- Glucose → pyruvic acid → lactic acid + energy
- The reaction is anaerobic.
- The energy yield is 2 ATP.
- It takes place in the sarcoplasm.
- The enzymes involved include LDH and PFK.
- Lactic acid is a fatiguing by-product.
- 4** Newton's first law (inertia): an object will remain in a constant state of motion unless acted upon by an unbalanced force. For example, a 400m runner remains at rest in the starting blocks until they apply an unbalanced force to the blocks and accelerate.
- Newton's second law (acceleration): acceleration is proportional to the mass of an object and the force applied to it. For example, the greater the force an athlete applies to the blocks, the faster they will accelerate.
- Newton's third law (reaction): for every action force, there is an equal and opposite reaction force. For example, the athlete applies a force to the ground and the ground applies a ground reaction force to the athlete of equal size and in the opposite direction.

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