Unit 3 – Movement Skills and Energy for Physical Activity

AREA OF STUDY 1 – HOW ARE MOVEMENT SKILLS IMPROVED?
Biomechanics - Kinetic Concepts
A force is a “push” or a “pull” with the objective of altering the state of motion of a body (i.e. speed up/slow down/stop or change direction.

Forces that oppose motion include:

- gravity (pulling objects back to earth)
- air resistance (the flow of air around an object)
- fluid resistance (the flow of water around an object)
- friction (when two surfaces contact each other)
**Force**

- **Internal forces** are the result of muscular contractions.
- **External forces** are the forces from outside sources.

*For example being punched in boxing.*
Gravity

- Gravity is a constant force that pulls objects down towards earth.
- It is gravity that holds stationary objects in place.
- It is gravity that creates a projectile's parabolic flight path.
Air Resistance

- Air Resistance
  - Air resistance acts in the opposite direction to a projectile’s flight and slows its horizontal velocity.
  - Therefore air resistance reduces the horizontal distance a projectile will travel.
When swimmers move through water the layers of water near the body get disturbed and mixed together and create turbulence.

Swimmers can reduce the effects of fluid resistance by:

- shaving body hair
- wearing swim caps
- adopting a streamlined body position
Friction

- Friction is a force that opposes motion.
- Friction occurs when there is movement of one body across another.

**Sliding Friction**

- In sports like skiing and ballroom dancing, participants try to reduce the friction of one surface sliding across another by using waxes and polishes.
- In other sports such as athletics and football, where athletes do not want to slip, sliding friction is increased by wearing spikes, stops or blades.
Rolling Friction – in sports like soccer and lawn bowls where a ball rolls across a contact surface, rolling friction will depend on:

- the nature of the surface of the ball
- the nature of the surface the ball rolls across
- the radius of the ball (a larger ball will have a greater contact surface and therefore more friction)
- the weight of the ball (friction is directly proportional to the weight of the ball)
Mass vs Weight

- **Mass** - is a measure of how much matter is in an object. It remains the same regardless of the gravity acting on the object.

- **Weight** – is the force that gravity exerts on an object.

- \( \text{Weight} = \text{mass} \times \text{gravity} \)

- Therefore an object would weigh less on the moon because the gravity acting on it is less than the gravity acting on it on earth.
Inertia

- **Inertia** is:-
  - a body’s reluctance to change its state of motion.
  - directly proportional to its mass.
- Therefore the greater an object’s mass, then the greater resistance it has to change and therefore the greater the force required to change its state of motion.

A shot put has a large mass and therefore a large inertia.
Linear momentum is the amount of motion of a moving body.

Linear momentum = mass \times velocity

(unit = \text{kg/m/sec})
Conservation of Linear Motion

- The total momentum of objects before a collision is equal to the total momentum of the objects after the collision.
- Therefore the total momentum of a golf club and ball before collision is equal to the total momentum of the club and ball after the collision.
Angular Momentum

- **Moment of Inertia** – is a measure of an object’s reluctance to rotate.
  - $I = \text{mass} \times \text{radius}^2$

- For example a tennis racquet’s moment of inertia will be determined by its mass and length.

- An object that is twice as long as another of the same mass will be four times harder to swing.
Angular Momentum

- **Angular Velocity** – is how quickly an object is spinning around its axis.
- Angular velocity = **Angular displacement / time**
  - (unit of measurement = degrees/sec)
Once airborne, Angular Momentum cannot be altered as there is nothing to push or pull against in mid air.

Therefore a decrease in moment of inertia will be met with a corresponding increase in angular velocity.

For example a diver changing from a straight to pike position will decrease radius (and therefore moment of inertia) and increase angular velocity (spin faster).

Decrease radius/moment of inertia.
Increase angular velocity.
Simultaneous summation of momentum involves all body parts acting together at the same time to generate force. Example sprint start.

Sequential summation of momentum involves all body parts contributing in sequence to generate force. Example golf drive.
The keys to successful sequential summation of momentum:

- use as many body parts as possible
- start with the heavier (slower) body parts and move through to the lighter (faster) body parts.
- each body part should stabilise so that the next body part has a stable base to accelerate upon.
- **TIMING** – each body part should commence action when the previous part has reached its optimal acceleration.
Summation of Momentum – Golf Swing Timing
Impulse is the change in momentum of a body.

\[ \text{Impulse} = \text{Force} \times \text{Time} \]

The greatest changes in momentum (whether speeding up or slowing down) will occur when maximum forces are applied for as long as possible.

The same principle of impulse applies for receiving forces.

Therefore for catching a fast moving ball the best result will be achieved if the force of the ball can be received over a longer time by “giving with the ball” as it is caught.
Newton’s Laws of Motion

- **Newton’s First Law of Inertia**
  - An object will remain at rest or in its current state of motion unless acted upon by an external force.
  - For example a soccer ball will roll across the pitch until another player traps or kicks it.
  - OR
  - A golf ball will remain still until the golfer strikes it with the club.
Newton’s Laws of Motion

- **Newton's Second Law of Acceleration**
  - Represented by the equation:
    - \[ \text{Force} = \text{mass} \times \text{acceleration} \]
  - The acceleration of an object will be:
    - in the direction of the force
    - in proportion to the size of the force
  - An object with a greater mass will require a greater force to accelerate it to the same degree.

For example a shot put will be hard to accelerate because of its mass.
Newton’s Laws of Motion

- Newton’s Third Law of Action – Reaction
  - For every “action” there is an equal and opposite “reaction” force
  - Baseball hit
    - Action – bat striking ball
    - Reaction – force of the ball back on the bat
  - Sprint start
    - Action – runner pushes on the blocks
    - Reaction – opposite force from the blocks propels the runner forward

For example a shot put will be hard to accelerate because of its mass.
Revision Questions

1. Internal forces are produced by:
   a. gravity.
   b. friction.
   c. muscles.
   d. water resistance.

2. Linear Momentum is:
   a. the amount of acceleration of a body.
   b. acceleration times mass of a body.
   c. mass times velocity of a body.
   d. always changing when a body is moving.

3. A basketball centre weighing 90 kg. collides with a guard weighing 70 kg. Both players were prepared for the contact but the centre was knocked to the floor.
   a. both players were travelling at the same speed.
   b. the centre was travelling twice as fast as the guard.
   c. the guard was travelling twice as fast as the centre.
   d. none of the above.

4. An example of an activity involving simultaneous force summation is:
   a. cricket bowling.
   b. goal shooting in netball.
   c. a high jump take-off.
   d. a hockey drive.
5. In order to effectively summate forces:
   a. the muscles with the least inertia should initiate the movement.
   b. the muscles with the greatest inertia should initiate the movement.
   c. the larger muscles apply their forces toward the end to build power.
   d. the faster muscles must be utilised first.

6. Which of the following is true?
   a. Rolling friction is less than sliding friction.
   b. Rolling friction is equal to sliding friction.
   c. Rolling friction is greater than sliding friction.
   d. none of the above.

7. List four external forces that can act on a body.
   Answer: - gravity, friction, air resistance, fluid resistance.

8. What is the formula for impulse?
   Answer: - Force X Time

9. Give four examples of activities with sequential force summation.
   Answer: - tennis forehand, punt kick, baseball pitch, discuss.

10. Give three examples of activities where friction is increased to improve performance.
    Answer: - studs on football boots, wax on surfboard, slick tyres on a racing car.
**Revision Questions**

11. If the radius of a tennis racquet is doubled, what is the effect on moment of inertia?
   a. it stays the same
   b. it is doubled \((X \ 2)\)
   c. it is tripled \((X \ 3)\)
   d. it is quadrupled \((X \ 4)\)

12. The greater an object’s mass then:
   a. the greater its inertia.
   b. the greater is the force required to move it.
   c. the greater is its resistance to change.
   d. all of the above.

13. In biomechanical terms, explain why a gymnast must tuck tightly when performing a triple somersault.

   Answer: By tucking the radius is reduced and therefore so is the moment of inertia. Because angular momentum is conserved in airborne activities, any reduction in moment of inertia is met by an increase in angular velocity – allowing the gymnast to spin quickly.
14. Give three examples of activities where friction is decreased to improve performance.

Answer: wax on dance floor, polishing bowling ball, skinny bike tyres.

15. Name and define Newton’s three laws of motion:

Answer:

1\textsuperscript{st} LAW OF INERTIA – an object at rest or in motion will continue in that state of motion unless acted upon by a force.

2\textsuperscript{nd} LAW OF ACCELERATION – (F = \textit{M} \times \textit{A}) – the acceleration of a body is directly proportional to the size of the force.

3\textsuperscript{rd} LAW OF ACTION & REACTION – for every action there is an equal and opposite reaction.