BIOMECHANICS & SPORTS

Key Points:

- Projectile & factors affecting projectile trajectory
- Angular & Linear movement
- Introduction to Work, Power & Energy
- Friction
- Mechanical Analysis-Walking & Running
  - The differentiate between walking & running

10.1 Biomechanics

- "Biomechanics is the science concerned with the internal & external forces acting on a human body & effects produced by these forces".

- Applications of Biomechanics in sports:-
  * Sports performance
  * Injury preventions
  * Rehabilitations
  * Sports mastery

- Scope of Biomechanics in sports:-
  * Designing of techniques
  * Designing of equipments & facilities
BIOMECHANICS & SPORTS

Potential Energy
(PE=Mgh)

Kinetic Energy
(KE=1/2mv^2)

Scope & Importance

Projectile
Energy
Work (W=F*D)
Motion
Friction

10.2A Factors affecting projectile trajectory

- Directions
- Angle
- Height
- Speed/velocity
- Air resistance
- Gravity
- Spin
B. Projectile & factors affecting Projectile Trajectory

- Speed of Release
- Angle of Release (Trajectory of Relax)
- Height of Release

10.3 Motion (Movement)

- Linear Motion
- Angular Motion
- Combination Motion

10.4 Introduction of Work, Power & Energy

10.5 Friction

* Type of Friction
* Coefficient of Friction
* Application of Friction in the field of sport
10.6A. Mechanical Analysis of walking
   - Stance phase
     * Heel strike
     * Early flat foot
     * Late flat foot-early heel rise
     * Heel rise
     * Toe off
   Swing phase

10.6B. Running
   - Stance phase
     * Initial contact/float stage
     * Absorption stage
     * Midstance stage
     * Propulsive stage

10.7 Differentiate-Running and Walking

**VERY SHORT ANSWER TYPE QUESTION (1 MARK EACH)**

Q1. Define trajectory?
Ans. The flight path followed by a projectile is called it's trajectory.

Q2. What do you mean by sport biomechanics?
Ans. Sport biomechanics is the study of forces and stresses of human movements & their effects, athletics performance and safety.

Q3. What is power?
Ans. The rate of doing work or using energy is called Power.
Power = \frac{\text{work done}}{\text{time taken to do work}}

Q4. Define Work?
Ans. Work refers to an activity involving a force and the movement in the direction of the force. It can also be defined as the work done by a constant force as the product of force and the distance moved in the direction of the force.

Work Done = \text{Constant force} \times \text{Distance moved in the direction of the force}

Q5. Explain Gravity?
Ans. Gravity is the force of attraction exerted by the earth towards its centre on a body or an object.

Q6. What is Air-resistance?
Ans. When a projectile moves through the air, it is slowed down by air-resistance.

Q7. Define velocity?
Ans. The distance covered by an object per unit time is called velocity.

SHORT ANSWER TYPE QUESTION (80 TO 90 WORDS) - (3 MARKS EACH)

Q1. What is Energy? Explain about Kinetic & Potential Energy?
Ans. The Energy is the capacity to do work. There are various forms of energy.

\textbf{Kinetic Energy}:- It is defined as energy possessed by a body as a result of motion. It is called as—Kinetic energy = \frac{1}{2} \text{mass} \times \text{velocity}^2 (\frac{1}{2}mv^2)

\textbf{Potential Energy}:- It is energy which is stored up in a body because of its position.

\textbf{Potential Energy} = \text{mass} \times \text{gravitational force} \times \text{height of the body from ground (mgh)}
Q2. Differentiate between Linear and Angular Motion?

Ans. Motions (Momentum) means a Change of position of a body and consists of the upsetting the equilibrium of a body.

**LINEAR MOTION**

When a body moves in a straight line, from one point to other in the same direction, is called linear motion.

- Linear Motion is measure in feet, meters, KM etc.
- Lines Motion is of two types:
  - **Curvy liner motion** - It is used when body travels on a curved path.

**ANGULAR MOTION**

When a body rotates it turns about an Axis, this rotation of the body is called angular motion.

- Angular motion is of two types:
  - **Visible Axis** - It is that type which can see for example - hands of a clock.
  - **Invisible** - An imaginary axis is that which can not be seen. The axis is the centre of the gravity of the body. For example - A Ball rotated in the air.
Q3. What is Friction? Discuss various types of Friction.

Ans. Friction is the force that combats relative motion between the two surfaces that come in contact. Friction always acts in the opposite direction of the applied force. Friction can be of following types:

**Static friction**:-the opposite force that comes into play when one body tends to move over the surface of another, but the actual motion has not yet started.

**Dynamic friction**:-the opposing force that comes into play when one body is actually moving over the surface of another body. Dynamic friction may be of two types.

**Rolling friction**:-the opposing force that comes into play when body is actually rolling over the surface of another body. For example, hockey/cricket ball is hit

**Sliding friction**:- The opposing force that comes into play when one body is actually sliding over the surface of the other body. For example- Ice skating.
Q4. Difference between Running and walking?
Ans.-

<table>
<thead>
<tr>
<th>Running</th>
<th>Walking</th>
</tr>
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<tbody>
<tr>
<td>- Running is a process, in which both feet are off the ground.</td>
<td>Walking is a process, in which at least one part of body (foot) remains in contact with the ground.</td>
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<tr>
<td>- There is a double swing phase and the swing phase is longer.</td>
<td>There is longer stance phase whereas swing phase is shorter.</td>
</tr>
<tr>
<td>- The linear and angular velocity of lower limbs is faster</td>
<td>The linear and angular velocity of lower limbs is slower.</td>
</tr>
<tr>
<td>- Running requires greater range of motion</td>
<td>Walking requires lesser range of motion</td>
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</tbody>
</table>

Q5. Is friction advantageous or disadvantageous in the field of games and sports? Give your comments with examples.
Ans. Friction is usually called necessary evil. It means it is essential in the life and we can not do any work without it.

<table>
<thead>
<tr>
<th>Advantages of friction</th>
<th>Disadvantages of friction</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Keeps the object at position:- By friction, the objects can be placed at position and shaped.</td>
<td>a. Wear and tear of object:- Due to friction, there is wear and tear of objects. Lubrication is used to allow the parts to move easier, moreover, prevents wear and tear.</td>
</tr>
<tr>
<td>b. Helps to move:- Frictional forces helps to move the object by friction. It helps in running, walking. With friction of feet/shoes on the surface, helps to speed. Frictional force helps to move the object in the speed. For example:- Spikes are used by the athletes to run fast.</td>
<td>b. Wastage of Energy:- Excess of friction means extra energy, thus energy is being wasted.</td>
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</tbody>
</table>
### Advantages of friction

c. Hold or grip an object:— with the help of friction the ridges of skin of our fingers and our palm enable us to grab and hold objects. For example— in badminton the players use grip to hold it.

d. Produce heat:— The law of conservation of energy states that the amount of energy remain constant. Thus, the energy that is lost due to friction in trying to move and object is really turned into heat Energy.

### Disadvantages of friction

c. Slow down the Speed:— In the roller Skating, Rolling Shoes and smooth surface are used to minimize friction.

d. Makes movement difficult:— Friction can make the job more difficult when one has to move the object. Excess friction can make it difficult to slide a box across the floor, walk through deep snow.

### Long Answer Type Question (5 Marks Each)

Q1. What is Projectile? Explain the factors affecting projectile trajectory?

Ans. **Projectile:**— An object thrown into the space either horizontally or an acute angle under the action of gravity is called a projectile. There are forces which act on a projectile—gravitational force and air resistance. Air resistance of an object varies greatly and it depends on the object’s particular shape and the atmospheric conditions in which the object is released.

The factors affecting Projectile Trajectory are mentioned below.

a. **Angle of projection:**— An object which is projected at different angles covers different distances. When it is projected or released at angle of 30, making it a parabolic path and covers lesser distance. When it is projected at 60, it covers a distance less than 30. When it is released at an angle of 45, makes a parabolic path and covers maximum
distance. So the distance covered by an object (short-put, hammer, javeline, discus etc. depends on the angle of release of projectile)

b. Height of release:- The higher the level of release, the greater distance is covered in flight, this is because the higher projectile is released. The longer it will be in the air. The horizontal component will be acting on the projectile for longer.

c. **Speed of release (initial velocity)**:- The speed or velocity is directly related to the distance covered in flight. The speed of release depends on initial vertical velocity and initial horizontal velocity. Having higher horizontal velocity will increase the length of flight time and therefore the distance covered. This would be an advantage in sports which primarily requires good distance in long jump, sky jump etc.

d. **Gravity**:- gravity acts on a body or object to give it mass. The greater the weight of an object, the greater the influence of gravity upon it. Gravity will effect a projectile as well as it will decrease the height, the projectile can obtain. For example:- a cricket ball can be thrown at greater distance in comparison to shotput.

e. **Air Resistance**:- When a projectile moves through the air, it is slow down by an air resistance. Air resistance decreases the horizontal component of a projectile. The effect of air resistance is very small but it need to be taken into consideration if you want to increase the horizontal components of a projectile. The factors are related to the amount of air resistance acting on a projectile-mass, surface of the object, surface of the volume ratio.
f. **Spin:** The amount and direction of spin acting on a projectile will directly effect the distance while travel.

The main reason behind this fact is the air pressure acting on the object.

Q2. Discuss the mechanical analysis of walking in details?

**Ans.** Mechanical analysis of walking can be studied in two fields:

**Stance phase:** Stance phase is the time, when the foot is on the ground. It is considered that it consists of maximum percentage of walking cycle. For the part of stance phase, both the feet have a contact with the ground for a period of time. The stance phase of walking is divided into five stages.

- **Heel Strike** - This stage begins when the feet first touches the ground and continuous until the complete foot is on the ground i.e. early flat foot stage.

- **Early Flat Foot** - The starting of this stage is that movement when the complete foot is on the ground and early flat foot stage occurs when the body’s centre of gravity passes over the top of the foot. The centre of gravity of the body is located approx. In the pelvic area of the lower spine while walking. The main purpose of this stage is to allow the foot to act as a shock absorber.

- **Late Flat Foot** - An athlete comes into late flat foot stage when his body’s centre of gravity passes in front of ‘neutral position. This stage lasts when the heel lifts off the ground. During this stage the foot needs to go from being a shock absorber to being a rigid lever which can help to propel the body in forward direction.

- **Heel Rise** - This stage starts when the heel begins to leave the ground. The foot functions are a rigid lever to move the body in forward direction. During this stage of walking, the ground forces that go through the foot are very efficient. -Toe off-this stage begins when the toes leave the ground completely. This stage continues until the beginning of swing phase.

**Swing Phase:** It occurs when one foot is on the ground and other one is in the air. Swing phase in walking is shorter than The stance phase. It is divided into three phases.
Initial swings: This phase sees the hip extended to 10\(^\circ\) and then going onto flexion and knee flexed to 40-60\(^\circ\) and the Ankle changing it's position from the flexion to neutral.

Mid swing: This phase sees the hip extended to 30\(^\circ\), the knee flexion till 60\(^\circ\) and extended approx to 30\(^\circ\) and ankle become dorsiflexed.

Terminal Swing: This phase is the hip flexed till 30\(^\circ\) and the knee is locked extension and foot changes its position from Dorsiflexed to neutral.

Q3. What are the different phases of running cycle?

Ans. Running is an essential part of living beings. Running is important in sports also. A good runner will not only be able to defeat it's opponents in running, but would also be able to gain very good takeoff velocity that would help to take a higher or longer jump.

Different phases of running are mentioned below.

<table>
<thead>
<tr>
<th>Running Style/Phases</th>
<th>Sprinting</th>
<th>Fast Running</th>
<th>Jogging</th>
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<tbody>
<tr>
<td>Initial Contact</td>
<td>This phase sees the front of the foot of the sprinter making contact with the ground. Their heel might or might not touch the ground later depending on their personal running technique.</td>
<td>This phase sees the middle of the foot or the heel of the fast runner make contact with the ground.</td>
<td>This phase sees the full foot or the heel of the jogger make contact with the ground.</td>
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<tr>
<td>Mid-Stance</td>
<td>This phase is very quick and the sprinter’s foot is usually in the same position as in the phase of initial contact.</td>
<td>This phase is very quick and the fast runner will spend this phase in mid-stance as he pushes through with this foot.</td>
<td>In comparison to sprinters and fast runners who use their feet and ankle to move into the next phase, joggers tend to move their centre of gravity forward to do the same.</td>
</tr>
<tr>
<td>Propulsion</td>
<td>This phase sees the hips of the sprinter extending back ready to propel him forward for take-off. His</td>
<td>The fast runner receives propulsion through the big toe with his hips extended</td>
<td>The jogger will receive propulsion through the big toe. But if the hips of the jogger are not fully</td>
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<td></td>
<td>arms simultaneously swing at full power to help him.</td>
<td>back and knee slightly bent.</td>
<td>extended back, then the propulsion is received from the other toes. The arms of the jogger only move a small amount.</td>
</tr>
<tr>
<td>Swing</td>
<td>The non-supporting leg of the sprinter swings high with the knee at almost at an angle of $90^\circ$.</td>
<td>The knee of the non-supporting leg of the fast runner will be lifted, although not as high as that of a sprinter.</td>
<td>The knee of your non-supporting leg of the jogger remains low and only slightly bent.</td>
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</tbody>
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