***Year 11 ATAR  
Physical Education Studies***

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***Biomechanics***

***Part A***

**Total Mark: /**

**Percentage: %**

***STUDENT NAME: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_***

**Application of Biomechanical Principles to Sport**  
*Purpose:*

To examine how the laws of motion and the principles of projectile motion influence a specific skill and how they can be used to improve performance.

*Design:*

Part A

* Watch a video of a netball player and complete the table on each movement phase of a netball shot.

Part B

* Students perform thorough warm-up with emphasis on upper body and trunk.
* Students use each of the conditions in the table and record the distance each throw.

*Equipment:*

* Shot Putt
* Tape measure
* Softball

*Data Collection:*

The students should collect results in the tables below

Part A:

Using the video clip <https://www.youtube.com/watch?v=N20vo_pXNnU> or <https://www.youtube.com/watch?v=wGUXLyYXvzU> analyse an elite player’s performance and completing the table below.

Analyse the skill through the **preparation, action** and **follow through** stage. State the major muscles, bones, joints and types of joints involved, as well as the type of movement created.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Action | Major muscles involved | Major bones involved | Joints and joint type | Movement created |
| **Preparation** |  |  |  |  |
| **Action** |  |  |  |  |
| **Follow through** |  |  |  |  |

Part B:

Throw a shot putt using the following conditions below and record the distance using a tape measure, collect an average not the furthest distance.

|  |  |
| --- | --- |
| **Condition** | **Distance (m)** |
| Front on, arm only (no trunk rotation) |  |
| Side on, arm and trunk only (no legs) |  |
| Side on, arm, trunk and legs |  |
| Side on, arm, trunk, legs, transfer of weight, feet can leave the ground, full rotation |  |
| Full spin or glide technique |  |
| Throw a softball ball with full sequential body movement. |  |

*Questions:*

*Part A Questions:***(40 marks)**

Using the video clip <https://www.youtube.com/watch?v=N20vo_pXNnU> or <https://www.youtube.com/watch?v=wGUXLyYXvzU> analyse an elite player’s performance by explaining which of the following biomechanical concepts have an influence on the performance of shooting in netball **during each of the three phases of preparation, action/execution and follow through.**

Biomechanical concepts to consider in your analysis:

Linear motion (speed, acceleration, velocity) Projectile motion, Angular Motion, Principle of Balance (static, dynamic, centre of gravity, Newton’s Law’s, summation of force and sequential vs simultaneous movements)

*Part B Questions:*

1) Describe every aspect of the journey of the shot put in relation to Newton’s First Law of Motion from the moment it is picked up by the athlete until it comes to a state of rest after being put. **(6 marks)**

2) Explain why the shot put travelled different distances on each occasion in relation to Newton’s Second Law of Motion. **(2 marks)**

3) Explain how the velocity of release and height of release influence the optimal angle of release for a shot put. **(6 marks)**

4) Explain the principle of force summation (sequential verse simultaneous). Describe the difference in segmental interaction between the shoulder, elbow and wrist joints for the shot put, in comparison to throwing a cricket or softball. **(6 marks)**

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**ANSWER KEY**

# Netball shot – MARKING KEY

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| Description | Marks |
| **Preparation phase**  Correct identification and biomechanical explanation of the movement involved during the preparation phase of the skill: (4 Movements) | **16 marks**=  1 mark for each correct identification of a movement during this phase (max. 4 marks)  3 marks for each biomechanical explanation (max. 12 marks) |
| **Action phase**  Correct identification and biomechanical explanation of the movement involved during the action phase of the skill (4 Movements) | **16 marks=**  1 mark for each correct identification of a movement during this phase (max. 4 marks)  3 marks for each biomechanical explanation (max. 12 marks) |
| **Follow through phase**  Correct identification and biomechanical explanation of the movement involved during the follow through phase of the skill (2 Movements) | **8 marks=**  1 mark for each correct identification of a movement during this phase (max. 2 marks)  3 marks for each biomechanical explanation (max. 6 marks) |

# Preparation Phase

In this phase of shooting, the player receives the ball and regains their balance, making sure they’re feet are shoulder width apart and facing the goal. The player ensures their fingers are spread around behind the ball and moves their arms into a high position, bent behind the ball aiming towards the goal.

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| **Biomechanical Principle** | **Influence on Performance** |
| **Linear Motion**  -speed  -acceleration  -velocity | The incoming ball is received at a high speed due to the fact that it is usually a short pass into the goal circle. After the player receives it, there is no motion and therefore no linear velocity or acceleration.  Linear motion- body parts square to post to ensure every moves in a straight line. |
| **Projectile Motion**  -optimal projection  -trajectory  -release of projectiles (angle, height, velocity) | **N/A**- the ball remains in the player’s hands during the preparation phase so there is no projection at this point in time  Preparing for a high release. |
| **Angular Motion**  -angular velocity | **N/A-** angular velocity is the angular displacement/time, since there is no displacement there is no angular velocity in this phase. |
| **Principle of Balance**  -centre of gravity  -static balance  -dynamic balance | Centre of gravity remains inside the body as the player is in an upright position. By keeping the trunk upright, the player maintains their balance. There is no dynamic balance as the player is stationary, however they have static balance as the body is in equilibrium all body parts are stationary). The player increases their stability by ensuring they have a wide base of support. This is done by having their feet shoulder width apart |
| **Newton’s Laws of Motion**  -inertia  -acceleration  -action/reaction | Newton’s First Law occurs in the preparation phase as it states that an object at rest will remain at rest unless a force it applied. This is seen as the netball remains in the players hands whilst they are preparing. |
| **Coordination of Linear Motion**  -sequential vs. simultaneous  -summation of velocity | Shooting requires sequential movement as the legs (larger muscles) move to create a stable base of support, followed by the arms moving above the head so the hands (smallest segments) are free to move for the player to aim accurately. |

# Execution Phase

The execution phase is when the player releases the ball to shoot a goal. The player combines actions of the arms and legs to form one complete motion. They player’s knees are slightly bent and they push forward onto their toes. At the same time, the player drops their wrist back slightly and extends their arms and the fingers push towards the goal, releasing the ball upwards and forwards.

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| **Biomechanical Principle** | **Influence on Performance** |
| **Linear Motion**  -speed  -acceleration  -velocity | The layer releases the ball and it will accelerate upwards until it reaches its maximum height, then it accelerates down due to gravity into the net. |
| **Projectile Motion**  -optimal projection  -trajectory  -release of projectiles  (angle, height, velocity) | The optimal angle of release is greater than 45˚, as a high trajectory ensures a longer flight time over a shorter distance. The vertical velocity of release is more than the horizontal velocity as the ball travels up vertically. The height of release is lower than the net; therefore the trajectory up is greater than the trajectory down. |
| **Angular Motion**  -angular velocity | Angular velocity is required in the execution phase as the backspin of the ball makes 1-1.5 rotations. This improves accuracy as it ensures the direction the ball travels. |
| **Principle of Balance**  -centre of gravity  -static balance  -dynamic balance | Whilst executing the shot, the player’s centre of gravity remains inside the body however it is higher as the player rises onto their toes. As the body is moving, dynamic balance is required. This allows the body to remained balanced whilst in motion. |
| **Newton’s Laws of Motion**  -inertia  -acceleration  -action/reaction | In the execution phase, the Law of Inertia comes into play as the player uses force to move the ball and it continues in motion until another force acts upon it (the net). The 2nd Law is applied because the more force that the ball is released at means that the acceleration will increase and the ball will continue to travel in the right direction towards the goal. The 3rd Law is applied if the goal is missed. This will mean the ball bounces off the hoop and it exerts force in the opposite direction (reaction force). If the ball does land in the net, it will have less reaction force to bounce off the ring. |
| **Coordination of Linear Motion**  -sequential vs. simultaneous  -summation of velocity | The execution involves sequential movement as the movement begins in the bending of the knees which transfers the power through the legs and trunk into the shoulders and through the arms to the fingertips where the ball is released. |

# Follow Through Phase

The last phase of shooting is the follow through. In this phase the arms fully extend and the wrists cock towards the ball. The player flicks their fingers on release to ensure the ball goes high enough to get a goal. The player’s hands should follow through to reach up towards the goal, allowing the ball to travel in the same pathway.

|  |  |
| --- | --- |
| **Biomechanical Principle** | **Influence on Performance** |
| **Linear Motion**  -speed  -acceleration  -velocity | **N/A-** as the ball has already been released, there is no speed, acceleration or velocity in the follow through phase. |
| **Projectile Motion**  -optimal projection  -trajectory  -release of projectiles  (angle, height, velocity) | **N/A-** the ball has already been released which means the player can only follow through and watch the ball to ensure they finish the skill correctly and score. |
| **Angular Motion**  -angular velocity | **N/A-** angular motion is not able to be controlled once the ball has left the players hands |
| **Principle of Balance**  -centre of gravity  -static balance  -dynamic balance | The centre of gravity remains inside the body and the player’s base of support remains stable. There is static balance present as the player is once again stationary. |
| **Newton’s Laws of Motion**  -inertia  -acceleration  -action/reaction | The Law of Inertia is applied in the follow through as air resistance can at as an unbalanced force which can alter the path of the ball. By following through with the hands, the player increases the stability of the netball during its flight time. |
| **Coordination of Linear Motion**  -sequential vs. simultaneous  -summation of velocity | Simultaneous movement happens during this phase because the player follows through the movement by flicking their wrists and fingers up towards the goal at the same time. |

*Questions:*

1) Describe every aspect of the journey of the shot put in relation to Newton’s First Law of Motion from the moment it is picked up by the athlete until it comes to a state of rest after being put.

(6 marks)

|  |  |
| --- | --- |
|  | 1 mark |
| Explanation of Newton’s 1st Law | An object will remain in its state of motion or rest unless acted upon by a force of sufficient magnitude to change its state of motion or rest |
| Picking shot up | When the athlete picks up the put he/she exerts a muscular force of sufficient magnitude in order to change its state of rest and move it |
| Throw | The athlete exerts a large muscular force against the put causing it to accelerate out of the hand and upwards through the air |
| Flight | Gravity exerts a non-contact force on the put as it travels through the air, drawing it back down to the ground |
| Landing | The put pushes its mass into the ground and the ground exerts a force on the put causing it to stop its flight |
| Roll | The put then starts to roll but the friction of the ground causes it to stop rolling |

2) Explain why the shot put travelled different distances on each occasion in relation to Newton’s Second Law of Motion. (2 marks)

|  |  |
| --- | --- |
|  | 1 mark |
| Explanation of Newton’s 2nd Law | Explains or understands that force = mass x acceleration or the greater the force applied the greater the acceleration of the projectile |
| Application | The throws that went further had a greater force applied to the shot put causing it to have greater acceleration or the shorter throws had less force applied to the shot put causing it to have less acceleration |

3) Explain how the velocity of release and height of release influence the optimal angle of release for a shot put. (6 marks)

|  |  |  |
| --- | --- | --- |
|  | 1 mark | 2 marks |
| Velocity of release | Demonstrates an understanding that the velocity of release decreases with an increase in the angle of release **or** that the optimal angle of release is less than 45 degrees in order to maintain a high velocity of release | As for 1 mark but also provides a reason why the velocity of release decreases with an increase in the angle of release e.g. the putter has to expend more energy in overcoming the weight of the shot put as the angle of release increases **or** a putter is able to exert a greater force horizontally than vertically. |
| Height of release | States that the height of release is greater than the landing height and that this reduces the optimal angle of release | As for 1 mark but demonstrates an understanding of why the height of release being greater than the landing height reduces the optimal angle of release i.e. a lower than 45 degree angle of release leads to greater horizontal displacement when the height of release is greater than the landing height **or** accurately discusses asymmetrical trajectory shape |
| Angle of release | Demonstrates an understanding that under ideal circumstances the optimum angle of release is 45 degrees **or** that the optimal angle of release of the shot put is between 30-40 degrees. | Demonstrates an understanding that under ideal circumstances the optimum angle of release is 45 degrees **and** that the optimal angle of release of the shot put is between 30-40 degrees. |

4) Describe the difference in segmental interaction between the shoulder, elbow and wrist joints for the shot put in comparison to throwing a cricket or softball. (6 marks)

|  |  |  |
| --- | --- | --- |
|  | 1 mark | 2 marks |
| Force summation |  | Defines sequential force summation **and** simultaneous force summation |
| Shot Put | Describes simultaneous segmental interaction | Provides reason – i.e. greater mass of the shot put or injury prevention |
| Cricket/Soft Ball Throw | Describes sequential segmental interaction | Provides reason – allows for the generation of high velocities through summation of force |