Biomechanics – Chapter A: Mechanics (Puzzle Scenarios)

Puzzle 1: The Worker's Box Lift

Arjun, a physiotherapy intern, observes a factory worker lifting a 20-kg box from the ground. The worker bends his spine forward, knees extended, and pulls the load upward. Arjun notices the worker struggles midway due to loss of balance.

Question: Which biomechanical principle explains the difficulty?

Options:

1. Loss of equilibrium due to a shifted center of gravity
2. Insufficient muscle torque at the knee joint
3. Lack of friction between shoes and ground
4. Improper lever arm alignment of the spine

Answer & Reasoning:

👉 **Option 1.** The worker's forward trunk bending moves the **center of gravity (COG) outside the base of support**, creating instability. Without squatting (using knee extensors), the spine acts as a long lever, increasing strain and reducing equilibrium.

Puzzle 2: Basketball Jump Shot

During a basketball match, a student observes a player leaping for a jump shot. At peak height, the player's body sways backward.

Question: Why does the sway occur?

Options:

1. Inertia maintains the upward momentum
2. Gravity acts through the line of gravity behind the base of support
3. Air resistance pushes the trunk backward
4. Torque generated by arm swing destabilizes equilibrium

Answer & Reasoning:

👉 **Option 2.** At maximum jump height, the **line of gravity shifts behind the feet**, reducing balance. With no stable base in midair, equilibrium is lost, and the player sways.

Puzzle 3: Crutch Walking Challenge

A patient using axillary crutches places them too far forward. The physiotherapy student notices the patient nearly tipping over.
Question: What is the mechanical error?
Options:

1. Reduced lever arm of shoulder muscles
2. Narrow base of support and unstable equilibrium
3. Excessive torque at the hip joint
4. High coefficient of friction between crutch tips and ground
   Answer & Reasoning:
   👉 **Option 2.** The crutches positioned too far forward create a **narrow and unstable base of support**, shifting the LOG outside. This compromises equilibrium.

Puzzle 4: Resistance Band Training

During rehab, a therapist applies a resistance band at the wrist for shoulder abduction. A student questions why the patient finds it harder than resistance at the elbow.
Options:

1. Increased moment arm of the resistance force
2. Shortened muscle length-tension relationship
3. Lower efficiency of scapular stabilizers
4. Increased angular velocity at shoulder joint
   Answer & Reasoning:
   👉 **Option 1.** Applying resistance distally increases the **moment arm** of external force,

raising torque demand at the shoulder.

Puzzle 5: The Runner's Sudden Stop

A sprinter abruptly halts after a 100m dash. His body jerks forward despite trying to stop.
Options:

1. Loss of balance due to anterior pelvic tilt
2. Newton's first law of inertia
3. Reduced torque at hip extensors
4. Lack of reaction force from the ground
   Answer & Reasoning:
   👉 **Option 2.** The runner continues moving forward due to **inertia (Newton's first law)** until friction and muscular force stop motion.

Puzzle 6: Balancing on One Leg

A ballet dancer balances on one leg. The student notes her slight trunk shift over the stance limb.
Options:

1. To increase angular momentum
2. To align LOG within the base of support
3. To reduce lever arm of hip abductors
4. To increase torque at the ankle
   Answer & Reasoning:
   👉 **Option 2.** Trunk shifting keeps the **line of gravity (LOG) within the stance foot's base of support**, ensuring balance.

Puzzle 7: Pushing a Wheelchair

A physiotherapy intern struggles to push a loaded wheelchair up a ramp.
Options:

1. Reduced mechanical advantage of second-class lever
2. High rolling resistance and gravitational pull
3. Loss of stability due to narrow wheelbase
4. Reduced torque at the shoulder
   Answer & Reasoning:
   👉 **Option 2.** Uphill motion increases **resistive force of gravity** and rolling friction, requiring higher applied force.

Puzzle 8: Tug of War in College Sports

Two teams pull a rope in opposite directions. The intern asks: what determines the winning side?
Options:

1. Greater torque at the shoulder joint
2. Higher ground reaction force and friction
3. Wider base of support
4. Shorter lever arm of applied force
   Answer & Reasoning:
   👉 **Option 2.** Victory depends not just on arm force but on **ground reaction force and friction** between feet and ground, preventing slipping.