



JHARKHAND RAI UNIVERSITY

RANCHI

LAB MANUAL

BIOMECHANICS - I

BPT III

LIST OF PRACTICAL

BIOMECHANICS - I

(23A302P)

S.NO	PRACTICAL
1.	Identification of anatomical pulley in body
2.	Identification of different types of lever in human joints
3.	Identification of different kinds of motion
4.	To find out relation between Centre of gravity (COG), Line of gravity (LOG) and Base of Support BOS)
5.	Identification of different kinds of posture

PRACTICAL 1

Aim: Identification of anatomical pulley in body

Fixed Pulley:-

The pulley is attached to the fixed point, the fixed pulley is acting as the first order lever. This type of pulley is used to alter the direction of the force by which the resistance or the traction can be applied to the body parts.

An improved muscle action comes from the muscle-tendon passing over external support, the external support serving as the pulley.

Example:

In the knee complex, the presence of the patella improves the efficiency of the quadriceps muscle as the pulley will increase the angle of insertion of the patellar ligament into the tibial tuberosity.



Patella acting as Fixed Pulley in Knee joint

The action of the muscle at the joint is altered because of the pulley.

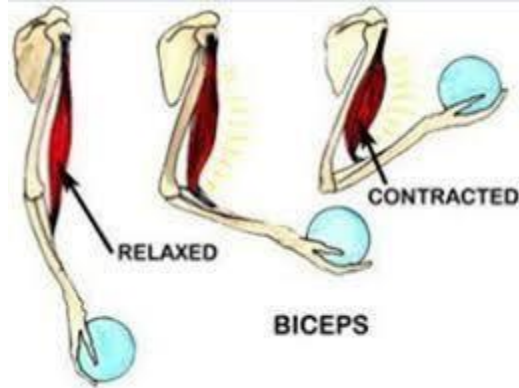
1. **The lateral malleolus of the fibula** acts as a pulley for the peroneus longus muscle. If it was not for the malleolus, this muscle instead of passing behind the lateral malleolus to be inserted in the base of the first metatarsal and to produce ankle plantar flexion and eversion, it would have produced ankle dorsiflexion and eversion because of its passage in front of the ankle joint. So here, the pulley is a bone (lateral malleolus acts as a pulley for peroneus longus muscle).
2. **The trochlea of the eye** allows the superior oblique muscle of the eye when it passes over it to rotate the eye obliquely. Without this pulley, the muscle would have little effect on the eye. The pulley is cartilage.
3. **The flexor retinaculum of the hand** act as a pulley for the flexor of the finger to prevent its bowstring. Without this action, these muscles will not be effective in moving these joints. The pulley is a ligament.

Movable Pulley

This type of pulley is also called the movable pulley, the muscle acts as a pulley the muscle is its own pulley.

Example:

The biceps muscle increase in size so because of that its angle of insertion will increase. The muscle underneath acts as a pulley for another muscle, which passes over it. e.g brachialis will raise the biceps giving it a better angle of insertion.



Biceps acting as movable pulley

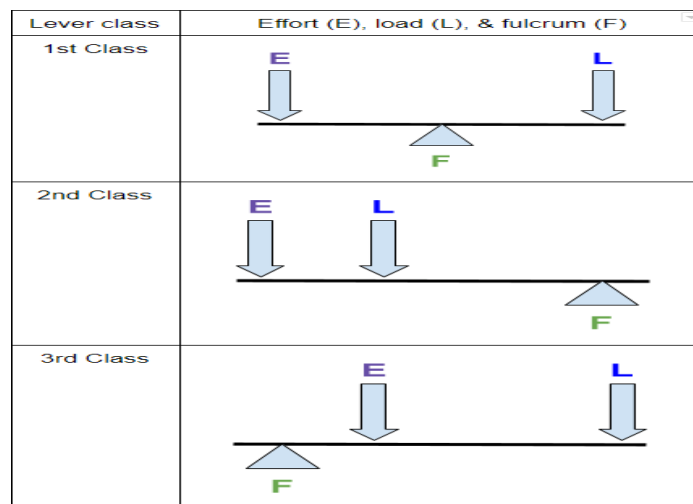
PRACTICAL 2

Aim: Identification of different types of lever in human joints

Some synovial joints have more efficient lever systems, we must first understand the relationships between the three lever parts: an effort or force applied to the lever, a fulcrum, and a load. A synovial joint also has these: effort (a muscle's applied force at the insertion site of a bone), a fulcrum (the joint axis), and a load (the body part/weight to be moved).

The Three Types of Levers

There are three different kinds of levers: first class, second class, and third class. Each of these lever classes have unique arrangements of the muscle's insertion (effort) and bones (lever/arm) around the joint (fulcrum). See the chart below to visualize the difference between the levers:

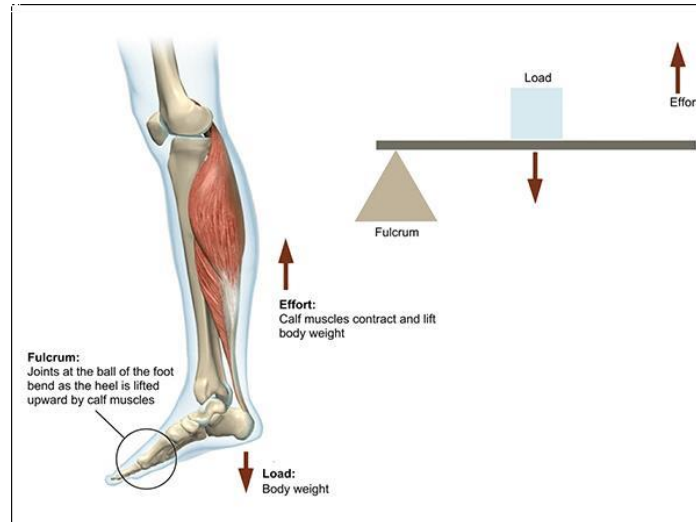


Different Types of Pulley

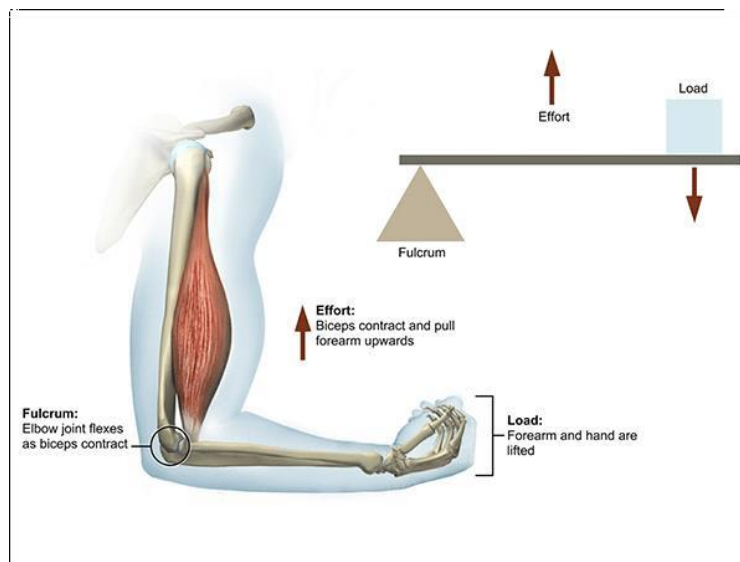
Effort Arm vs. Load Arm

The efficiency of a lever relies on the ratio of the **effort arm** to the **load arm**. The **effort arm (EA)** is the distance between the fulcrum and the effort; in the body, this is the distance between the joint and the muscle's insertion site. The **load arm (LA)** is the distance between the fulcrum and the load; in the body, this is the distance between the joint and the loaded body part.

The greater the ratio of the effort arm to the load arm, the more efficient the lever system is (i.e. the easier it is to move the load). Therefore, if the distance between a muscle's insertion site and the joint is greater than the distance between the load and the joint, your muscle is at an advantage. This is why your gastrocnemius can lift more weight than your bicep, even if they are equally as strong.



Gastrocnemius muscle acting as 2nd order lever



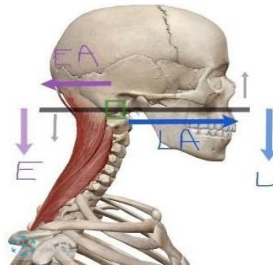
Biceps muscle acting in 3rd order lever.

A first class lever system with a shovel and cinder block. You strategically position the cinder block so that when you use it as leverage, the middle of the shovel handle rests on it. Now, when you put your hands on the end of the shovel to apply a downward force (effort) that leverages the rock (load), your hands and the rock are equally distant from the cinder block (fulcrum). Thus, your effort arm and load arm are equal.

To make it even easier, you could move the cinder block closer to the rock, moving the fulcrum closer to the load. This decreases the load arm and increases the effort arm, making the lever more efficient and allowing you to lift the rock while applying less force.

Atlanto-Occipital Joint as a First Class Lever

An example of a first class lever in the human body is the head and neck during neck extension. The fulcrum (atlanto-occipital joint) is in between the load (front of the skull) and the effort (neck extensor muscles). The muscles are attached to the posterior part of the skull to allow for the greatest effort arm. The atlanto-occipital joint in the middle provides leverage, and when the muscles contract, pulling the occipital bone down, the front of the skull is lifted



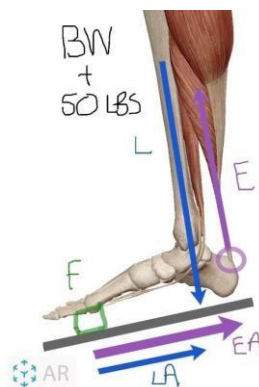
The atlanto-occipital joint as a first class lever.

The Calf as a Second Class Lever

The gastrocnemius in your calf, however, is at a mechanical advantage. In plantar flexion, the lower leg acts as a second class lever. A second class lever is the only lever that can promise that the effort arm will always be greater than the load arm. This arrangement results in a bigger effort arm to load arm ratio, making the second class lever the most mechanically advantageous.

In a calf raise, the effort comes from the gastrocnemius muscle, which is attached to your calcaneus bone. The load comes from your body weight and the extra weight you are holding; this force acts on the lever system through the tibia. The fulcrum is made up of the metatarsophalangeal joint.

In this arrangement, the load is in the middle, and the effort is farthest from the fulcrum. Therefore, the act of plantarflexion can move much more weight than elbow flexion, even if your bicep is just as strong as your calf.

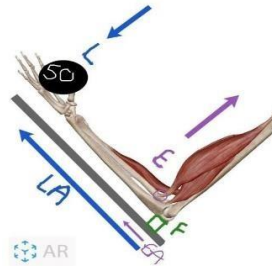


The calf as a second class lever.

Elbow Joint as a Third Class Lever

Examples of the third class lever system are abundant in the human body. In our case of a weighted bicep curl and a calf raise, the lever system involved in a bicep curl is mechanically less efficient than the lever system involved in a calf raise. The elbow joint is an example of a third class lever, operating with the effort between the load and fulcrum.

The distance between the elbow joint and the insertion site of the bicep tendon is very small, especially when it's compared to the distance between the elbow joint and the weight in your hand. The effort arm is significantly shorter than the load arm, making the ratio very small. When you try to curl the weight, your bicep has to work harder because it is at a mechanical disadvantage.



The elbow joint as a third class lever.

PRACTICAL 3

Aim: Identification of different kinds of motion

Motion of a body can be described only if we know its position with respect to time. In order to study motion more easily, we classify motion as linear, rotary, and general.

Linear Motion

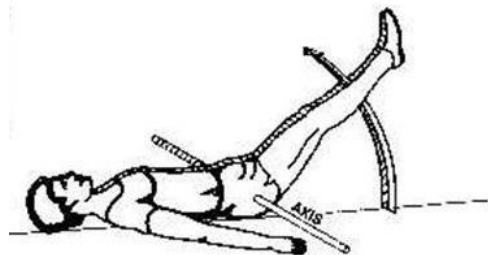
In linear motion all particles of human body travel the same distance during the same time. Linear motion can be further divided to rectilinear motion and curvilinear motion. In rectilinear motion all particles of the body travel the same distance along parallel straight lines. In curvilinear motion the trajectories of individual particles of the body are curved, although the orientation of the body in space does not change. As an example of rectilinear motion we can imagine a downhill skier going down along the fall line of a flat inclined plane. A good example of curvilinear motion is a gymnast on a trampoline who keeps his/her body in the same position but lands on a spot different from take-off.

Rotary Motion

In rotary motion all particles of human body travel along a circle or its part, unless they are in the axis of rotation.

Rotary motion (angular motion) of a body can take place about an axis that passes through the body or about an axis that does not pass through the body. A gymnast swinging on the rings is an example of rotary motion about an axis that does not pass through the body. Figure skater rotating on ice rink is an example of rotary motion about an axis that passes through the body.

Individual parts of human extremities also carry out rotary motion with their joints as axes.

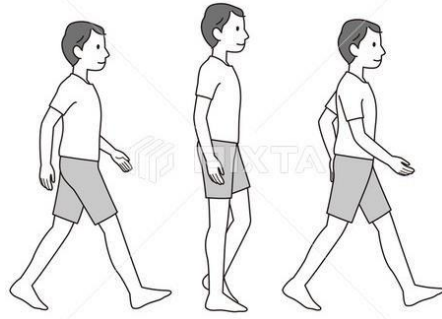


Rotatory motion around a axis

General Motion

General motion is a combination of linear and rotary motions.

General motion is the most common type of motion in sport and physical exercise. Running and walking are among typical examples. In this case the trunk moves in linear motion as a result of rotary motions of individual segments of extremities. Riding a bicycle is another example of general motion.



Walking is a general motion

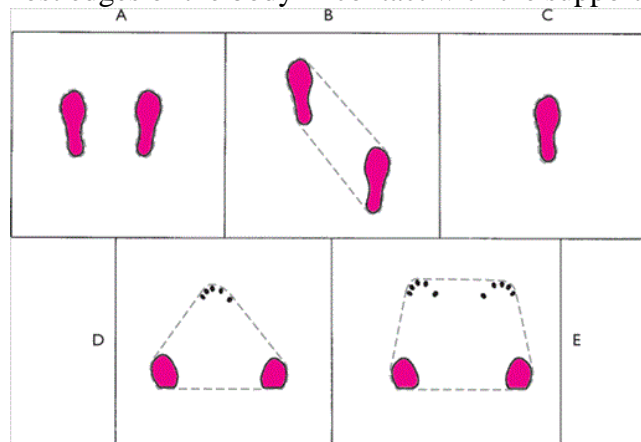
PRACTICAL 4

Aim: To find out relation between Centre of gravity (COG), Line of gravity (LOG) and Base of Support BOS)

The principles of equilibrium is stability. Stability is defined mechanically as resistance to both linear and angular acceleration, or resistance to disruption of equilibrium. In some circumstances, such as a Sumo wrestling contest or the pass protection of a quarterback by an offensive lineman, maximizing stability is desirable. In other situations, an athlete's best strategy is to intentionally minimize stability. Sprinters and swimmers in the preparatory stance before the start of a race intentionally assume a body position allowing them to accelerate quickly and easily at the sound of the starter's pistol. An individual's ability to control equilibrium is known as balance.

Different mechanical factors affect a body's stability. According to Newton's second law of motion ($F = ma$), the more massive an object is, the greater is the force required to produce a given acceleration. Football linemen who are expected to maintain their positions despite the forces exerted on them by opposing linemen are therefore more mechanically stable if they are more massive.

Another factor affecting stability is the size of the base of support. This consists of the area enclosed by the outermost edges of the body in contact with the supporting surface or surfaces

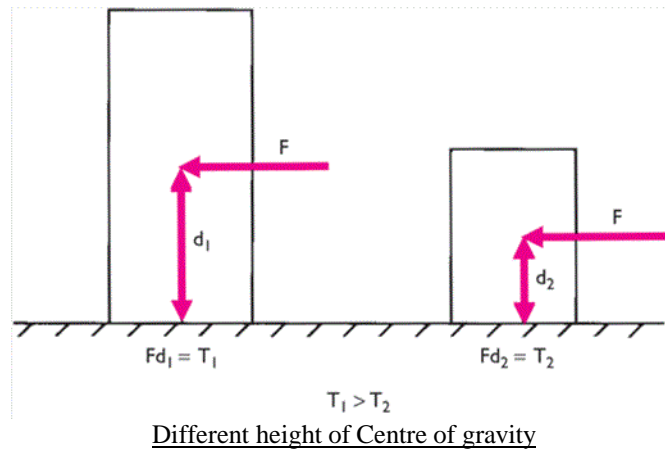


Different types of base of support

When the line of action of a body's weight (directed from the CG) moves outside the base of support, a torque is created that tends to cause angular motion of the body, thereby disrupting stability, with the CG falling toward the ground. The larger the base of support is, the lower is the likelihood that this will occur. Martial artists typically assume a wide stance during defensive situations to increase stability. Alternatively, sprinters in the starting blocks maintain a relatively small base of support so that they can quickly disrupt stability at the start of the race.

Maintaining balance during an *arabesque en pointe*, in which the dancer is balanced on the toes of one foot, requires continual adjustment of CG location through subtle body movements. The horizontal location of the CG relative to the base of support can also influence stability. The closer the horizontal location of the CG is to the boundary of the base of support, the smaller is the force required to push it outside the base of support, thereby disrupting equilibrium.

The height of the CG relative to the base of support can also affect stability. The higher the positioning of the CG, the greater the potentially disruptive torque created if the body undergoes an angular displacement.



PRACTICAL 5

Aim: Identification of different kinds of posture

Posture

Posture is body alignment. The relative arrangement of parts of the body. Changes with the positions and movements of the body throughout the day and throughout life.

The posture maintained in the trunk and positioning of the vertebral segments (stresses imposed upon the spine). The spine (vertebral column) has to meet 2 functions Strength Mobility Posture and life cycle.

Infants' ability to assume and maintain upright posture is limited because their postural reaction still need to be perfected. Upright standing posture is inherently unstable because the body's centre of gravity is situated high above a relatively small base of support

Spine curvature – In the neonate: the whole spine is flexed forming a 'C' shaped curve (convex posteriorly) from the occiput to the sacrum- when the infant begins to lift his head: the cervical curve reverses to become convex anteriorly- As the toddler begins to sit and stand: the lumbar curve reverses like the cervical. Once the standing posture is achieved the spine has four curves:

1. Cervical curvature: convex anteriorly (secondary)
2. Thoracic curvature: convex posteriorly (primary)
3. Lumbar curvature: convex anteriorly (secondary)
4. Sacral curvature: convex posteriorly (primary)

Posture and Life cycle

In old age: The shape of the spine tends to revert back to the 'C' shaped spinal flexibility is greatly reduced in some elders. The cervical curve may increase as they try to keep their eyes directed parallel to the floor, so that they can look ahead. The seven ages of man abnormal posture

Lordosis: an increase in the anterior lumbar curve

Kyphosis: an increase in the posterior thoracic curve

Scoliosis: lateral curvature of spine

High heels shoes throw the body weight forward, so the spine may adapt by increasing the lumbar curvature (lordosis)

Scoliosis may affect the shape of the thorax, which may create problems in breathing

Abnormal posture

Degenerative changes in the spine due to disease or aging may lead to permanent deformity standing posture

To maintain upright standing posture, the "S" shaped spine acts as an elastic rod to support the weight standing posture

Since the center of gravity lies in front of the spine a continuous forward bending moment is imposed upon the trunk in standing the posterior muscles and ligaments must control and maintain the standing posture standing posture

Erect posture: activity in the erector spinae muscle (trunk extensors)

Slouched posture: the ligaments and joint capsules take most of the responsibility for maintaining the posture Postural sway • Standing is not a static position: the upright position is

maintained by the alternating action of various muscles to keep the body's centre of gravity over the base of support. The magnitude of larger in the very old and very young

Postural Sway: Prevents fatigue (because of the alternating periods of activities and inactivity in the motor units). Its assist venous return. It is affected by ¾ Vision ¾ Ankle and foot proprioceptors in standing position for long time.

Postural sway in standing is controlled by: ¾ erector spinae muscles, ¾ abdominal muscles, ¾ psoas major muscle. All of these muscle is slightly active in standing position with more activity in the thoracic region than the lumbar and cervical region.

Standing posture

The ideal standing posture is one in which the line of gravity runs: ¾Through the mastoid process ¾Just in front of the shoulder joint ¾Just behind the hip joint ¾Just in front of the center of the knee joint ¾In front of the ankle joint Line of gravity Standing posture

An ideal balanced posture reduces the work needed by the muscles to maintain the body in erect position standing posture

Muscles active in standing: ¾Soleus is continuously active because gravity tends to pull the body forward over the feet ¾Iliopsoas remains constantly active ¾Gluteus medius and tensor fascia lata are active to counteract lateral postural sway ¾Erector spinae muscles are active to counteract gravity's tendency to pull the trunk forward Sitting posture

Requires less energy expenditure and imposes less load on the lower limb than standing

But, prolonged sitting can have negative effects on the lumbar spine sitting posture.

Unsupported sitting: high muscle activity in the thoracic region, with low levels of activity in the abdominals sitting posture

Unsupported sitting places more load on the lumbar spine because it creates: ¾a backward pelvic tilt ¾a flattening of the lower back ¾forward shift in the center of gravity places load on the discs and the posterior structures of the vertebral column (ligaments, capsules, muscles) Sitting posture • Supported sitting: the load on the lumbar vertebrae is less than unsupported sitting



Sitting posture

Prolonged sitting in a flexed position may: ¾increase the resting length of the erector spinae muscles ¾overstretch the posterior ligamentous structures Sitting posture • Ergonomic intervention: ¾Raising the height of the work station (to reduce flexion of the cervical and lumbar regions) ¾The use of foot rest (to relieve strain) ¾Symmetrical working position (to reduce the incidence of twisting which stretches the posterolateral structures, particularly the annulus



Sitting Posture

Lifting Posture

Lifting may result in a back injury as a result of $\frac{3}{4}$ weight of the load. $\frac{3}{4}$ the distance of the load from the body. Identifying the best lifting strategy. Proper lifting posture is one in which $\frac{3}{4}$ back is erect, $\frac{3}{4}$ knees are bend, $\frac{3}{4}$ weight is close to the body, $\frac{3}{4}$ movement occurs through one plane only (Avoid twisting). Stooped lifting posture reduces the activity in the trunk extensor so the forward movement is resisted by passive structures (disc, ligaments, fascia) placing these structures at risk of injury.



Lifting Posture