Question 2

Stance Phase:

Initial Contact:

- The moment when the foot makes contact with the ground.
- Kinematics:
  - ❖ Ankle: Neither plantarflexed nor dorsiflexed.
  - ❖ Knee: It is slightly hyperextended.
  - ❖ Hip: It is flexed at around 30 degrees.
- Ground Reaction Force: A peak is observed as the heel makes impact on the ground.
- Moments induced and Power:
  - ❖ Ankle: A dorsiflexing moment would be acting opposing the GRF which will try to plantarflex the foot and hence power will be negative.
  - ❖ Knee: A flexing moment acts on the knee opposing hyperextension and the power is thus positive.
  - ❖ Hip: The GRF acts to flex the hip while the muscles try to extend it. As it is in overall motion direction the power is positive.
- Key Muscle Actions: To stop swinging of the leg, hamstrings provide eccentric action. The quadriceps cause the extension of the knee. The tibialis anterior prepares to act upon heel rocker.

Loading Response:

- This is the initial double support period when the limb is accepting the weight
- Kinematics:
  - ❖ Ankle: As heel-rocker takes place till the foot becomes flat the ankle plantarflexes.
  - ❖ Knee: The knee flexes and this provides shock absorption for heel contact.
  - ❖ Hip: Hip starts to extend from its flexed position.
- Ground Reaction Force: Along with opposition to vertical force the added friction causes the net GRF to act completely in the opposite direction of motion. The vertical GRF increases till maximum is reached.
- Moments induced and Power:

    - ❖ Ankle: A dorsiflexing moment would be acting opposing the GRF which will try to plantarflex the foot and hence power will be negative.
    - ❖ Knee: A flexing moment acts on the knee and the power is positive.
    - ❖ Hip: Hip shows extensor moment. The power is positive.
- Key Muscle Actions: The quadriceps contribute to controlled flexion of the knee. Gluteus maximus also acts in this phase. The tibialis anterior acts to pull the tibia as the person moves.

Mid Stance:

- The body advances over the supporting-limb and moves ahead of the stance-limb.
- Kinematics:
    - ❖ Ankle: The ankle rocker-motion and dorsiflexion of the foot occurs post-foot-flat position. The ankle reaches zero and moves beyond.
    - ❖ Knee: Continues flexing till it reaches 20 degrees and then extends till zero.
    - ❖ Hip: Extends till anatomical zero position and beyond.
- Ground Reaction Force: The net GRF decreases till a local minimum as foot flat is achieved. The GRF is almost vertical due to the reduction of horizontal GRF.
- Moments induced and Power:
    - ❖ Ankle: A plantarflexing moment is observed as the force now has shifted to the front and tries to dorsiflex the ankle. The power is negative.
    - ❖ Knee: A extensor moment is applied as the GRF tries to flex the knee. The power is positive.
    - ❖ Hip: The extensor moment decreases and becomes a flexion moment as the GRF is positive. The power transitions from negative to positive.
- Key Muscle Actions: The quadriceps and soleus muscles act in this phase. Soleus and Gastroc muscles act on the ankle in the later stage.

Mid Stance:

- This is the last phase of single-support and ends with opposite initial contact.
- Kinematics:
    - ❖ Ankle: Dorsiflexes till a maximum of 5-10 degrees and then plantarflexes as foot rocker takes place.
    - ❖ Knee: Stays extended and starts to flex towards the end.
    - ❖ Hip: Further extended until it reaches -20 degrees.

- Ground Reaction Force: The vertical GRF again starts increasing till it reaches a maximum as the leg prepares for push-off. The net GRF is in the direction of motion as friction acts forward accelerating the body as the body pushes the ground back.
- Moments induced and Power:
    - ❖ Ankle: The plantarflexing moment increases until a peak and then reduces slightly. Power is initially negative but then increases until a peak.
    - ❖ Knee: Turns extensor from flexor and power oscillates between positive and negative.
    - ❖ Hip: Continues to flex and absorbs power.
- Key Muscle Actions: Triceps surae acts to shift the foot forward to the forefoot rocker position.

Pre-Swing:

- The weight is shifted to the other limb as preparation for swing occurs.
- Kinematics:
    - ❖ Ankle: Due to forefoot rocker continues to plantarflex.
    - ❖ Knee: Continues flexion
    - ❖ Hip: Starts to flex.
- Ground Reaction Force: The foot starts to leave the ground after reaching a maximum and the other foot starts to accept the load. Thus the GRF decreases until lift off when it becomes zero.
- Moments induced and Power:
    - ❖ Ankle: As GRF reduces, the plantarflexion moment continues to decrease and the power generated also decreases.
    - ❖ Knee: The knee starts to flex due to hip flexion and thus an extensor moment is applied. The power is negative.
    - ❖ Hip: Still shows a flexor moment which is reducing and the power transitions from negative to positive.
- Key Muscle Actions: Iliopsoas acts to lift the leg. The quadriceps acts eccentrically to prevent flexion in the knee.

Swing Phase:

Initial-Swing:

- The first 1/3rd of the swing phase which ends with the knee being adjacent.
- Kinematics:
    - ❖ Ankle: Achieves maximum plantarflexion. Post this starts dorsiflexing to make clearance as the foot leaves the ground.
    - ❖ Knee: Flexes till a maximum of 45-60 degrees and then starts extending.
    - ❖ Hip: Flexes beyond the anatomical zero position.
- Ground Reaction Force: The GRF is zero as the foot is in the air.
- Moments induced and Power:
    - ❖ Ankle: A dorsiflexing moment is produced as the ankle starts to plantarflex due to gravity. The magnitude is negligible though.
    - ❖ Knee: A extensor moment is applied due to gravity and hip flexion. Power continues being absorbed.
    - ❖ Hip: Continues providing decreasing flexor moment. Power generation reaches maximum.
- Key Muscle Actions: The triceps surae start acting concentrically to dorsiflex the foot. The iliopsoas muscle continues to act to provide moments to lift the foot.

Mid-Swing:

- The second 1/3rd of the swing phase which ends with the tibia being vertical.
- Kinematics:
    - ❖ Ankle: Dorsiflexion continues beyond the neutral position.
    - ❖ Knee: Continues extending.
    - ❖ Hip: Flexes till maximum and stays there.
- Ground Reaction Force: The GRF is zero as the foot is in the air.
- Moments induced and Power:
    - ❖ Ankle: Continues showing negligible moment and power.
    - ❖ Knee: Shows flexor moment and power continues being negative.
    - ❖ Hip: Shows extensor moment and power is negative.
- Key Muscle Actions: The triceps surae acts in this phase. The hip flexor acts though the moment is low.

Terminal-Swing:

- The last 1/3rd of the swing phase and the gait cycle itself where the knee extends in preparation for the next initial contact.
- Kinematics:
    - ❖ Ankle: Dorsiflexion slightly and then plantarflexes in preparation for the next gait cycle.
    - ❖ Knee: Fully extends in preparation for the next gait cycle.
    - ❖ Hip: Stays at the maximum flexed position.
- Ground Reaction Force: The GRF is zero as the foot is in the air.
- Moments induced and Power:
    - ❖ Ankle: Continues showing negligible moment and power.
    - ❖ Knee: Shows flexor moment and power reaches maximum and decreases to zero.
    - ❖ Hip: Continues showing increasing extensor moment. Power is almost zero as the hip angle doesn't change much.
- Key Muscle Actions: The triceps surae contracts to keep the foot in place. Quadriceps act concentrically to extend the knee. Hamstrings provide an eccentric action.