Biomechanics Unit 1 - Introduction

STAGE 1 | DESIRED RESULTS

Standards

3.2.9-12.I Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

3.1.9-12.B Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

3.1.9-12.C Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

Transfer

Students will be able to independently use their learning to...

- ☐ Biomechanics is the application of mechanical principles in the study of living organisms.
- ☐ The human body can move as a whole (i.e. 100 m dash) or in parts (i.e. flex the elbow).

Meaning

UNDERSTANDINGS

Students will understand that...

- ☐ Biomechanics is the application of mechanical principles in the study of living organisms.
- ☐ The human body must be described and referred to using specific anatomical terminology, nomenclature, and equipment.
- ☐ The human body has a variety of joint types (i.e. hinge, ball-and-socket) to achieve different motions.

ESSENTIAL QUESTIONS

Students will keep considering...

- ☐ What is Biomechanics?
- ☐ How can qualitative and quantitative approaches be used to analyze human movement?
- ☐ How are qualitative analyses of human movement performed?
- ☐ Why is a common anatomical language necessary?
- ☐ How are body planes, axes, regional, and directional terms used to "map" out the human body?
- ☐ How is movement described scientifically?
- ☐ What tools are used to measure kinematic quantities?

Acquisition(need to align with above and standards)

Students will know...

PS2.A: Forces and Motion

- ☐ Newton's second law accurately predicts changes in the motion of macroscopic objects.

Key vocabulary/other knowledge:

- ☐ biomechanics

Students will be skilled at...

- ☐ *Define the terms biomechanics, statics, dynamics, kinematics and kinetics*
- ☐ *Explain the ways in which statics, dynamics, kinematics, and kinetics are related.*
- ☐ *Construct an explanation to distinguish between qualitative and quantitative approaches for analyzing human movement.*

	☐ dynamics/statics ☐ English system/metric system ☐ kinematics/kinetics ☐ kinesiology ☐ mechanics ☐ qualitative/quantitative ☐ sports medicine ☐ anatomical reference position ☐ axis of rotation ☐ cardinal planes ☐ frontal axis/longitudinal axis/sagittal axis ☐ frontal plane/sagittal plane/transverse plane ☐ general motion ☐ linear motion ☐ Newton's second law accurately predicts changes in the motion of macroscopic objects.	☐ *Explain how to formulate questions for qualitative analysis of human movement.* ☐ *Analyze and provide examples of linear, angular, and general forms of motion.* ☐ *Analyze, identify, and describe the reference positions, planes, and axes associated with the human body.* ☐ *Develop and use models requiring definitions and appropriate use of directional terms and joint movement analysis.* ☐ *Identify and describe the uses of available instrumentation for measuring kinematic quantities.*

Biomechanics Unit 2 - Kinematics

STAGE 1 | DESIRED RESULTS

Standards

3.2.9-12.I Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

3.1.9-12.B Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

3.5.9-12.I (ETS) - Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

3.5.9-12.K (ETS) - Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and

Transfer

Students will be able to independently use their learning to...

- ☐ Linear kinematics governs the movement of the human body and its segments.

Meaning

UNDERSTANDINGS

Students will understand that...

- ☐ Motion is relative.
- ☐ Motion can be described using position, velocity, acceleration and time.
- ☐ Mathematical and graphical models can be used to describe and predict bodily motion.

ESSENTIAL QUESTIONS

Students will keep considering...

- ☐ How is kinematic data collected?
- ☐ What is the difference between scalars and vectors?
- ☐ What is the relationship between position, displacement, velocity, and acceleration?
- ☐ What is the difference between average and instantaneous quantities?
- ☐ How is linear kinematics used in research studies?
- ☐ How do you solve quantitative problems that employ linear kinematic principles?
- ☐ How can human body movement be described scientifically?

Acquisition(need to align with above and standards)

Students will know...

PS2.A Forces and Motion

- ☐ Newton's second law accurately predicts changes in the motion of macroscopic objects.

ETS1.B: Developing Possible Solutions

- ☐ When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.
- ☐ Both physical models and computers can be used in various ways to aid in the

Students will be skilled at...

- ☐ *Analyze and interpret data to differentiate and classify human motion as linear, angular, or general*
- ☐ *Develop and use anatomical models or diagrams to accurately identify and describe standard reference positions, planes of motion, and axes of rotation relevant to human movement.*
- ☐ *Use anatomical directionality and joint movement vocabulary to construct explanations of movement*
- ☐ *Plan and carry out an effective qualitative human movement analysis*

constraints on interactions within and between systems relevant to the problem.	engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. *Other knowledge:* ☐ average ☐ initial velocity ☐ instantaneous ☐ kinematics ☐ laws of constant acceleration ☐ linear acceleration ☐ linear displacement ☐ linear velocity ☐ meter ☐ Newton's second law accurately predicts changes in the motion of macroscopic objects.	☐ *Use mathematical and computational thinking to apply appropriate SI units when describing and solving biomechanical problems involving mass (kg), force (N), weight (N), and torque (Nm)* ☐ *Construct explanations that describe how linear motion applies to different human movements*

Biomechanics Unit 3 - Human Balance

STAGE 1 | DESIRED RESULTS

Standards

3.2.9-12.I Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

3.2.9-12.J Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.

3.2.9-12.K Apply scientific and engineering ideas to design, evaluate and refine a device that minimizes the force on a macroscopic object during a collision.

3.2.9-12.O Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

Transfer

Students will be able to independently use their learning to...

- ☐ Angular kinetics governs the movement of the human body and its segments.

Meaning

UNDERSTANDINGS

Students will understand that...

- ☐ Torque depends on the magnitude of a force and the point of force application.
- ☐ Net torques cause changes in rotation.
- ☐ Centripetal force is required for motion along a curved path.
- ☐ Mechanical advantage is dependent on the placement of the force and fulcrum.

ESSENTIAL QUESTIONS

Students will keep considering...

- ☐ What is torque?
- ☐ What is the impact of Newton's Laws for human movement?
- ☐ What is moment of inertia?
- ☐ What is center of mass/center of gravity?
- ☐ How can the center of mass be calculated for a human body?
- ☐ What are the three classes of levers?
- ☐ How can you analyze single joint movement?
- ☐ What is stability and how does it affect human movement?
- ☐ How can you dynamically analyze single joint movement?
- ☐ What is the relationship between torque and balance?

Acquisition(need to align with above and standards)

Students will know...

PS2.A Forces and Motion

- ☐ Newton's second law accurately predicts changes in the motion of macroscopic objects.
- ☐ Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object.
- ☐ If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside of the system.

Students will be skilled at...

- ☐ *Define torque, quantify resultant torques, and identify the factors that affect resultant joint torques.*
- ☐ *Develop and use models to identify the mechanical advantages associated with the different classes of levers and explain the concept of leverage within the human body.*
- ☐ *Use mathematical and computational thinking to solve basic quantitative*

3.2.9-12.P Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects). 3.1.9-12.B Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. 3.1.9-12.C Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.	**PS3.A Definitions of Energy** ☐ Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as within the system, energy is continually transferred from one object to another and between its various possible forms. ☐ At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. **PS3.B. Conservation of Energy and Energy Transfer** ☐ Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. ☐ Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. ☐ Mathematics expressions, which quantify how the stored energy in a system depends on its configuration and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. *Other knowledge:* ☐ Balance, base of support. center of mass, center of gravity. Equilibrium. first-class lever. Fulcrum, lever, mechanical advantage, moment arm, second-class lever, stability, third-class lever. torque, centripetal force, principal axes	*problems using the equations of static equilibrium.* ☐ *Construct explanations to show the significance of center of gravity location in the human body.* ☐ *Construct an explanation to show how mechanical factors affect a body's stability.* ☐ *Develop and use models to explain why changes in the configuration of a rotating airborne body can produce changes in the body's angular velocity.* ☐ *Use mathematical and computational thinking to solve quantitative problems relating to the factors that cause or modify angular motion of the human body.*

Biomechanics Unit 4 - Work and Power

STAGE 1 | DESIRED RESULTS

Standards

3.2.9-12.I Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

3.2.9-12.J Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.

3.2.9-12.K Apply scientific and engineering ideas to design, evaluate and refine a device that minimizes the force on a macroscopic object during a collision.

3.2.9-12.O Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

Transfer

Students will be able to independently use their learning to...

- ☐ Linear kinetics govern the movement of the human body and its segments.
- ☐ The human body can complete work.
- ☐ Energy can be converted from one form to another.

Meaning

UNDERSTANDINGS

Students will understand that...

- ☐ Force and net force are not the same.
- ☐ When a force is exerted in the direction of an object's motion, work is done.
- ☐ The state of motion cannot change when there is no net force on a body.
- ☐ Energy exists in different forms and is conserved.
- ☐ Energy allows a body to move.
- ☐ Mass and velocity affect the momentum of a body.
- ☐ Energy conservation can be applied to human motion.

ESSENTIAL QUESTIONS

Students will keep considering...

- ☐ What is a force? How are forces used to complete work?
- ☐ How is work related to energy and Conservation of Energy?
- ☐ What are Newton's Laws of Motion and how do they relate to human movement?
- ☐ What is the difference between a contact and a noncontact force and how do they affect human movement?
- ☐ What is Newton's Universal Law of Gravitation and how does it affect human movement?
- ☐ How are free body diagrams used to represent external forces acting on a human body?
- ☐ What is the impulse-momentum theorem and how it affects human movement?
- ☐ What is the work-energy theorem and how it affects human movement?
- ☐ How is linear kinetics used in research studies?

Acquisition(need to align with above and standards)

Students will know...

PS2.A Forces and Motion

- ☐ Newton's second law accurately predicts changes in the motion of macroscopic objects.

Students will be skilled at...

- ☐ *Identify Newton's Laws of Motion and Gravitation and describe practical illustrations of the laws using human movement.*

3.2.9-12.P Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects). HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. HS-LS1-3 - Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.	☐ Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. ☐ If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside of the system. **PS3.A Definitions of Energy** ☐ Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as within the system, energy is continually transferred from one object to another and between its various possible forms. ☐ At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. **PS3.B. Conservation of Energy and Energy Transfer** ☐ Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. ☐ Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. ☐ Mathematics expressions, which quantify how the stored energy in a system depends on its configuration and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. *Other knowledge:* ☐ friction ☐ kinetic energy	☐ *Construct an explanation to show what factors affect friction and discuss the role of friction in daily activities and sports.* ☐ *Use mathematical and computational thinking to calculate impulse and momentum changes during collisions and explain the relationship between two bodies.* ☐ *Discuss the relationships among mechanical work, power, and energy as it relates to human movement.* ☐ *Use mathematical and computational thinking to solve quantitative problems related to kinetic concepts.*

	☐ kinetic friction ☐ linear momentum ☐ static friction ☐ normal reaction force ☐ potential energy ☐ power ☐ gravitational potential energy ☐ work	

Biomechanics Unit 5 - Biomechanics of Injuries

STAGE 1 | DESIRED RESULTS

Standards

3.2.9-12.I Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

3.2.9-12.J Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.

3.2.9-12.K Apply scientific and engineering ideas to design, evaluate and refine a device that minimizes the force on a macroscopic object during a collision.

3.2.9-12.O Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

Transfer

Students will be able to independently use their learning to...

- ☐ Angular kinetics governs the movement of the human body and its segments.

Meaning

UNDERSTANDINGS

Students will understand that...

- ☐ Forces and torques can cause injuries to bones and/or soft tissues in the human body.
- ☐ Proper techniques for sports can help athletes properly support movements to avoid injuries.
- ☐ Humans can use preventative techniques to avoid injuries.
- ☐ Newton's Laws can be applied to human movements to distribute forces and torques to avoid injuries.

ESSENTIAL QUESTIONS

Students will keep considering...

- ☐ What are forces and movements at major joints in the human body?
- ☐ How do forces and torques affect skeletal systems and soft tissues in the human body?
- ☐ How can the laws of motion be applied to prevent injuries?
- ☐ What is the impulse-momentum theorem and how it affects human movement?
- ☐ What is the work-energy theorem and how it affects human movement?
- ☐ How is linear kinetics used in research studies?

Acquisition(need to align with above and standards)

Students will know...

PS2.A Forces and Motion

- ☐ Newton's second law accurately predicts changes in the motion of macroscopic objects.
- ☐ Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object.
- ☐ If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside of the system.

PS3.A Definitions of Energy

Students will be skilled at...

- ☐ *Analyze and interpret data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.*
- ☐ *Define torque, quantify resultant torques, and identify the factors that affect resultant joint torques.*
- ☐ *Develop and use models to identify the mechanical advantages associated with the different classes*

3.2.9-12.P Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects). HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. HS-LS1-3 - Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.	☐ Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as within the system, energy is continually transferred from one object to another and between its various possible forms. ☐ At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. **PS3.B. Conservation of Energy and Energy Transfer** ☐ Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. ☐ Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. ☐ Mathematics expressions, which quantify how the stored energy in a system depends on its configuration and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. *Other knowledge:* ☐ Balance, base of support, force, torque, skeletal system, soft tissues (ligaments), equilibrium	*of levers and explain the concept of leverage within the human body.* ☐ *Use mathematical and computational thinking to solve basic quantitative problems using the equations of static equilibrium.* ☐ *Plan and conduct investigations to determine the location of the center of gravity in different postures (e.g., standing, squatting, leaning).* ☐ *Develop and use models to explain the significance of center of gravity location in the human body.* ☐ *Construct explanations to explain how mechanical factors affect a body's stability.* ☐ *Use mathematical and computational thinking to solve quantitative problems relating to the factors that cause or potentially cause injuries to the human body.* ☐ *Apply Newton's Laws of Motion and torques to physical movements of the human body to analyze injuries.*