East Penn School District
Curriculum and Instruction

Curriculum for: Special Topics: Physics of Movement (Biomechanics)

Course(s): Special Topics: Physics of Movement (Biomechanics)

Grades: 10-12

Department: Science

Length of Period (average minutes): 42

Periods per cycle: 6

Length of Course (yrs): 0.5

Type of offering: Elective

Credit(s) awarded: 0.5 4.0/4.0

Developed by: Kathryn Donnelly

ADOPTED: 2018

Enduring Understandings & Essential Questions	Knowledge	Skills	Standards
Enduring Understandings: ● 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: ● What is biomechanics? ● How can qualitative and quantitative approaches be used to analyze human movement? ● How are qualitative analyses of human movement performed?	● Biomechanics ● Dynamics/statics ● English system/metric system ● Kinematics/kinetics ● Kinesiology ● Mechanics ● Qualitative/quantitative ● Sports medicine ● Anatomical reference position ● Angular ● Axis of rotation ● Cardinal planes ● Curvilinear ● Frontal axis/longitudinal axis/sagittal axis ● Frontal plane/sagittal plane/transverse plane ● General motion ● Linear ● Rectilinear ● System ● Translation	● Define the terms biomechanics, statics, dynamics, kinematics and kinetics, and explain the ways in which they are related. ● Distinguish between qualitative and quantitative approaches for analyzing human movement. ● Explain how to formulate questions for qualitative analysis of human movement. ● Provide examples of linear, angular, and general forms of motion. ● Identify and describe the reference positions, planes, and axes associated with the human body. ● Define and appropriately use	NGSS Standards: ● HS-PS2-1. 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. ● PS2.A. Forces and Motion - Newton's second law accurately predicts changes in the motion of macroscopic objects ● HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. [Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system. ● HS-LS1-3.Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. [Clarification Statement: Examples of investigations could include heart rate response to exercise, stomate response to moisture and temperature, and root development in response to water levels.]

● 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?		directional terms and joint movement analysis. ● Identify and describe the uses of available instrumentation for measuring kinematic quantities.	
Enduring Understandings: ● 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: ● How is kinematic data collected? ● What is the difference between scalars and vectors? ● What is the relationship between position,	● Angle of projection ● Apex ● Average ● Initial velocity ● Instantaneous ● Kinematics ● Laws of constant acceleration ● Linear acceleration ● Linear displacement ● Linear velocity ● Meter ● Projectile ● Projection speed ● Range ● Relative projection height ● Trajectory	● Provide examples of linear, angular, and general forms of motion ● Identify and describe the reference positions, planes, and axes associated with the human body ● Define and appropriate use directional terms and joint movement terminology ● Explain how to plan and conduct an effective qualitative human movement analysis	NGSS Standards and Disciplinary Core Ideas ● HS-PS2-1. 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. ● PS2.A. Forces and Motion - Newton's second law accurately predicts changes in the motion of macroscopic objects ● HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. [Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system. ● HS-LS1-3.Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. [Clarification Statement: Examples of

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?		● Define and identify common units of measurement for mass, force, weight, torque ● Describe bodily movement using linear motion.	investigations could include heart rate response to exercise, stomate response to moisture and temperature, and root development in response to water levels.]
Enduring Understandings: ● Extremities rotate and/or move in a curved path. ● All joints have an accepted range of motion. ● Angular motion can be described using angular displacement, angular velocity, angular acceleration and time. ● Mathematical and graphical models can be used to describe and predict angular motion.	● Angular acceleration ● Angular displacement ● Angular velocity ● Body segment orientation ● Instant center ● Joint angle ● Radial acceleration ● Radian ● Radius of rotation ● Right hand rule ● Tangential acceleration	● Distinguish angular motion from rectilinear and curvilinear motion. ● Discuss the relationships among angular kinematics variables. ● Explain the relationships among angular and linear displacement, angular and linear velocity, and angular and linear acceleration.	NGSS Standards: ● HS-PS2-1. 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. ● PS2.A. Forces and Motion - Newton's second law accurately predicts changes in the motion of macroscopic objects ● HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. [Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system.

Essential Questions: ● What is the difference between linear, angular, and general motions? ● How do you measure relative and absolute angles? ● How do you calculate lower extremity angles? ● What is the relationship among the kinematic quantities of angular distance and displacement, angular velocity, and angular acceleration? ● What is the difference between angular and linear motions, particularly displacement, velocity, and acceleration? ● How is angular kinematics used in research studies of human movement? ● How do you solve quantitative problems that employ angular kinematic principles?		● Solve quantitative problems involving angular kinematic quantities and the relationships between angular and linear kinematic quantities. ● Describe bodily movement using angular motion.	● HS-LS1-3.Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. [Clarification Statement: Examples of investigations could include heart rate response to exercise, stomate response to moisture and temperature, and root development in response to water levels.]
Enduring Understandings: ● Force and net force are not the same.	● Coefficient of friction ● Coefficient of restitution	● Identify Newton's laws of motion and gravitation and describe practical	NGSS Standards: ● HS-PS2-1. Analyze data to support the claim that Newton's Second Law of Motion describes the

● 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. ● How mass and velocity affect momentum of a body. ● How momentum is transferred during a collision. ● What affects the force on an object during a collision. ● How energy conservation is related to the type of collision. Essential Questions: ● What is a force? ● How do you use vectors to add forces? ● 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?	● Friction ● Impact ● Kinetic energy ● Kinetic friction ● Linear momentum ● Maximum static friction ● Normal reaction force ● Perfectly elastic impact ● Perfectly plastic impact ● Potential energy ● Power ● Strain energy ● Work	illustrations of the laws using human movement. ● Explain what factors affect friction and discuss the role of friction in daily activities and sports. ● Define impulse and momentum and explain the relationship between two bodies. ● Explain what factors govern the outcome of a collision between two bodies. ● Discuss the relationships among mechanical work, power, and energy at it relates to human movement. ● Solve quantitative problems related to kinetic concepts.	mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. ● HS-PS2-2. 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. ● HS-PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. ● 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. ● HS-PS3-1. 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 ● HS-PS3-2. 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 position of particles (objects). ● 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.

● 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?			- 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. ● HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. [Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system. ● HS-LS1-3. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. [Clarification Statement: Examples of investigations could include heart rate response to exercise, stomate response to moisture and temperature, and root development in response to water levels.]
Enduring Understandings:	● Balance ● Base of support ● Center of mass ● Mass centroid	● Define torque, quantify resultant torques, and identify the factors	NGSS Standards: ● HS-PS2-1. Analyze data to support the claim that Newton's Second Law of Motion describes the

● Torque depends on force and where it is applied. ● Net torque causes change in rotation. ● Centripetal force is required for motion along a curved path. ● Mechanical advantage is dependant on the placement of the force and fulcrum. Essential Questions: ● What is torque? ● What are the angular analogue of Newton's Laws of Motion and what is their impact on human movement? ● What is 'moment of inertia'? ● How does angular momentum impact human motion? ● What is center of mass/gravity? ● How can you calculate segment and total body center of mass? ● What are the three classes of levers? ● How can you statically analyze single joint movement?	● Center of gravity ● Couple ● Dynamic equilibrium ● First-class lever ● Fulcrum ● Lever ● Mechanical advantage ● Moment arm ● Reaction board ● Second-class lever ● Segmental method ● Stability ● Static equilibrium ● Third-class lever ● Torque ● Angular impulse ● Angular momentum ● Centripetal force ● Moment of inertia ● Principal axes ● Principal moment of inertia ● Radius of gyration	that affect resultant joint torques. ● Identify the mechanical advantages associated with the different classes of levers and explain the concept of leverage within the human body. ● Solve basic quantitative problems using the equations of static equilibrium. ● Define center of gravity and explain the significance of center of gravity location in the human body. ● Explain how mechanical factors affect a body's stability. ● Identify the angular analogues of mass, force, momentum, and impulse. ● Explain why changes in the configuration of a rotating airborne body can produce changes in the	mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. ● HS-PS2-2. 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. ● HS-PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. ● 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. ● HS-PS3-1. 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 ● HS-PS3-2. 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 position of particles (objects). ● 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.

● What is stability and how does it affect human movement? ● How can you dynamically analyze single joint movement? ● What is the relationship between torque, angular work, rotational kinetic energy and angular power?		body's angular velocity. ● Identify and provide examples of the angular analogues of Newton's laws of motion. ● Define centripetal force and explain where and how it acts. ● Solve quantitative problems relating to the factors that cause or modify angular motion of the human body.	- 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. ● HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. [Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system. ● HS-LS1-3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. [Clarification Statement: Examples of investigations could include heart rate response to exercise, stomate response to moisture and temperature, and root development in response to water levels.]

Materials and Resources: Internet resources