Ohio Science - Extended Learning Standards

Physics

Motion

1 Motion Graphs • Position vs. time • Velocity vs. time • Acceleration vs. time P.M.1

Complexity a

a Complete a motion graph by indicating the sections where the object is speeding up, moving at constant speed, and slowing down. P.M.1.A

Complexity b

b Label areas of different motion on a motion graph. P.M.1.B

Complexity c

c Identify the motion of an object in a motion graph. P.M.1.C

Learning Progression

- Use a motion sensor to generate a motion graph of a toy car going down a ramp or a person's movement across a room. Describe the motion indicated by the graph. P.M.1.LP.A
- Match cards (e.g., moving at a constant speed, speeding up, slowing down) to sections of a speed vs. time graph. P.M.1.LP.B
- Match cards (e.g., standing still, moving forward, moving backwards, moving quickly, moving slowly) to sections of a position vs. time graph. P.M.1.LP.C
- Recognize that the y-axis of a speed vs. time graph indicates speed. P.M.1.LP.D
- Recognize that the y-axis of a position vs. time graph indicates location. P.M.1.LP.E
- Recognize that the x-axis of a motion graph indicates time elapsing. P.M.1.LP.F
- Identify the information that a motion graph reveals (e.g., standing still, moving forward/backwards, moving quickly/ slowly, speeding up/slowing down). P.M.1.LP.G
- Recognize that motion can be represented on a graph. P.M.1.LP.H

2 **Problem Solving • Using graphs (average velocity, instantaneous velocity, acceleration, displacement, change in velocity) • Uniform acceleration including free fall (initial velocity, final velocity, time, displacement, acceleration, average velocity)** P.M.2

Complexity a

a Use graphs to show that the free fall acceleration rate of varying objects, with negligible air resistance, is the same. P.M.2.A

Complexity b

b Make a prediction of the fall rate of two objects that have significantly different mass and surface area. P.M.2.B

Complexity c

c Drop two objects that have significantly different mass and surface area (e.g., a bowling ball and a feather) and make observations. P.M.2.C

Learning Progression

- Use computer simulations to produce graphs of various objects falling with negligible air resistance. Compare the graphs and show that they all accelerate at the same rate. P.M.2.LP.A
- Drop an object and time how long it takes to fall to the floor, suggest and test a change to the object that will make it fall more slowly (e.g., parachute, wings). Test the modification and describe increased air resistance is causing the object to fall more slowly. P.M.2.LP.B
- Watch a video of two objects falling in a vacuum and describe that the acceleration rate (due to gravity) is the same for both because there is no air resistance. P.M.2.LP.C
- Compare the fall rate of objects that have the same mass but different surface areas (e.g., a paper flat, one wadded up and one folded into fourths) by dropping them at the same time. Explain that air resistance affects the rate of falling. P.M.2.LP.D
- Predict which of two objects will fall fastest. Test the prediction. P.M.2.LP.E
- Drop objects and time how long they take to fall to the floor. P.M.2.LP.F

3 Projectile Motion • Independence of horizontal and vertical motion • Problem-solving involving horizontally launched projectiles P.M.3

Complexity a

a Determine whether a ball needs to be thrown higher (vertical) or farther (horizontal) for it to land in a designated area (e.g., in a hoop or on an “x” on the ground). P.M.3.A

Complexity b

b Identify the horizontal and vertical motions of a projectile. P.M.3.B

Complexity c

c Recognize that projectiles have movement in both horizontal and vertical directions. P.M.3.C

Learning Progression

- Use video simulations (such as cannon launch labs like https://phet.colorado.edu/en/simulation/projectile-motion) to change factors and see how they affect projectiles. Make an accurate prediction about the effect of a change in launch position. P.M.3.LP.A
- Measure the distance a projectile (launched straight forward) falls and compare this to the distance it falls if dropped and when launched harder. Notice that these vertical distances are all the same. Explain that the vertical motion of a projectile does not depend on its horizontal motion. P.M.3.LP.B
- Observe a graph (or drawing) of the path of a projectile to see that it is a curved line. Identify the horizontal and vertical changes on the graph. P.M.3.LP.C
- Launch a projectile and describe that it moves both horizontally (goes forward) and vertically (falls). P.M.3.LP.D
- Define vertical and horizontal. P.M.3.LP.

Forces, Momentum and Motion

1 Newton's Laws Applied to Complex Problems P.F.1

Complexity a

a Recognize that momentum is conserved in a collision. P.F.1.A

Complexity b

b Demonstrate Newton's Third Law: for every action, there is an equal and opposite reaction. P.F.1.B

Complexity c

c Identify the direction of an object's motion after it collides with another moving object. P.F.1.C

Learning Progression

- Explain that the total momentum of a system of objects is the same before and after they collide. P.F.1.LP.A
- Design a demonstration that shows momentum being transferred. P.F.1.LP.B
- Explain that when two objects collide momentum can be transferred from one object to another. P.F.1.LP.C
- Calculate the momentum of an object by multiplying its mass by its velocity. P.F.1.LP.D
- Add arrows (can be cards) to a picture (e.g., boy pulling wagon, bat hitting ball) to show that each object exerts a force on the other object and that the forces are the same size but in opposite directions. P.F.1.LP.E
- Explain that you can represent a force by an arrow that shows the direction and size of a force (longer arrows mean greater force). P.F.1.LP.F
- Use Newton's Third Law to identify that an object pulls or pushes back whenever you pull or push on it (e.g., pull on a rope tied to a stationary object to feel action/reaction forces; explain when you exert a force on the rope the rope exerts an equal force back on you which you can feel as the rope pulling you). P.F.1.LP.G
- Recognize that when you sit on a chair you are pushing down on the chair and the chair is holding you up. P.F.1.LP.H
- State a general rule for what happens when two moving objects collide. P.F.1.LP.I
- Roll two balls, carts or toy cars toward each other and describe their motions after colliding. P.F.1.LP.J
- Roll the ball from different angles and describe how the direction that the second ball moves changes. P.F.1.LP.K
- Roll a ball into a stationary ball and describe what happens to the motion of the balls (first one slows down, second one starts moving). P.F.1.LP.L

2 Gravitational Force and Fields P.F.2

Complexity a

a Explain the relationship between mass and gravitational pull. P.F.2.A

Complexity b

b Recognize that gravity is the force that keeps planets and satellites in circular orbits P.F.2.B

Complexity c

c Identify gravity as a force. P.F.2.C

Learning Progression

- Explain that more massive objects exert greater gravitational forces (e.g., Earth pulls on an object more than the moon does). P.F.2.LP.A
- Describe that gravity from the sun makes planets travel in circles and that Earth's gravity does the same to satellites including our moon. P.F.2.LP.B
- Recognize that circular motion requires a force toward the center of the circle (e.g., whirl a wiffle ball tied to a string in a circle and watch what happens if you release the string, observing appropriate safety precautions). Describe that your hand was exerting an inward force on the string. P.F.2.LP.C
- Identify that the force of gravity moves things (e.g., water flowing down a river, fruit falling from trees, balls rolling down ramps). P.F.2.LP.D
- Describe that objects fall because of the force of gravity. P.F.2.LP.E

3 Elastic Forces P.F.3

Complexity a

a Design a device that would propel an object using elastic materials (e.g., rubber band cars). P.F.3.A

Complexity b

b Make a prediction of the elasticity of two significantly different elastic materials. P.F.3.B

Complexity c

c Manipulate a variety of elastic bands and other elastic materials and make observations (e.g., rubber bands, hair bands). P.F.3.C

Learning Progression

- Design a device that uses elastic forces to propel an object. P.F.3.LP.A
- Manipulate elastic objects (e.g., balloons, physical therapy bands, bungee cords) and describe that the further each is stretched the harder it is to keep stretching them (observe safety considerations). P.F.3.LP.B
- Identify a way an elastic object could be used to make an object move. P.F.3.LP.C
- Given two dissimilar objects, predict which one will stretch the most. P.F.3.LP.D
- Recognize that not all elastic objects stretch the same amount (e.g., use a variety of different fabrics (denims), rubber bands or bungee cords to illustrate this point). P.F.3.LP.E
- Distinguish elastic from non-elastic objects. From a set of objects (or images) select the items that are elastic objects. P.F.3.LP.F
- Recognize that things which can stretch are elastic objects. P.F.3.LP.G

4 Friction Forces (Static and Kinetic) P.F.4

Complexity a

a Organize the surface types from “causes the most friction” (most difficult to push) to “causes the least amount of friction” (easiest to push). P.F.4.A

Complexity b

b Investigate friction as it relates to moving an object (e.g., sliding furniture over different types of flooring). P.F.4.B

Complexity c

c Recognize that diverse surface types cause friction differently. P.F.4.C

Learning Progression

- Define static friction as contact between two stationary surfaces which must be overcome to start an object moving. P.F.4.LP.A
- Define kinetic friction as contact between two moving surfaces. P.F.4.LP.B
- Order a given set of surfaces from produces the most friction to produces the least friction. P.F.4.LP.C
- Identify a way to move a heavy cabinet across a floor (adding wheels, sliding on a blanket). P.F.4.LP.D
- Identify ways to make a surface easier to slide across (sanding, adding a lubricant). P.F.4.LP.E
- Describe how different surfaces result in different amount of friction (e.g., slide a block down a ramp with different surfaces (wood, plastic, vegetable oil on the surface, sandpaper) to observe differences in speed)). P.F.4.LP.F
- Explain that frictions slows moving objects. P.F.4.LP.G

5 Air Resistance and Drag P.F.5

Complexity a

a Through investigation, determine the rate of fall of an object in air and a variety of liquids. P.F.5.A

Complexity b

b When given an object, make a prediction of its motion and rate of fall when dropped in the air and a variety of liquids. P.F.5.B

Complexity c

c Drop the same object in air and into a variety of liquids with different viscosity and make observations (e.g., oil, honey, and water). P.F.5.C

Learning Progression

- Explain how air resistance and drag affect the motion of objects moving through fluids (e.g., boats, kites, swimmers, airplanes). P.F.5.LP.A
- Explain how air resistance and drag affect the motion of falling objects. P.F.5.LP.B
- Describe which types of fluids allow materials to pass through them most easily. P.F.5.LP.C
- Describe air resistance and drag as forces that slow objects moving in fluids (liquids and gases). P.F.5.LP.D
- Drop a marble through various fluids (e.g., air, oil, syrup, water) and time how long it takes each to fall an equal distance. P.F.5.LP.E

6-7 Forces in Two Dimensions • Adding vector forces AND P.F.7 Momentum, Impulse, and Conservation of Momentum • Motion down inclines • Centripetal forces and circular motion P.F.6-7

Complexity a

a Identify the force that, if removed from an object moving in a circular motion, would cause the object to move in a straight line. P.F.6-7.A

Complexity b

b Indicate the direction of the centripetal force of an object moving in a circular motion (e.g., ball being swung on a string). P.F.6-7.B

Complexity c

c Recognize that gravity is the force that creates motion down an incline. P.F.6-7.C

Learning Progression

- Describe what occurs when the force acting toward the center of a circle is removed (e.g., watch videos such as https://www.youtube.com/watch?v=dxmedyNZ_8s that show what happens when a centripetal force is removed). P.F.6-7.LP.A
- Given objects in circular motion (e.g., ball on string, planet in orbit, ferris wheel) identify the agent and direction of the force causing each circular motion. P.F.6-7.LP.B
- Identify the force of gravity as the agent causing things to move down inclined surfaces . P.F.6-7.LP.C
- Identify examples of objects and substances moving down inclines (e.g., water flowing down a river, sled sliding down a hill, balls rolling down ramps). P.F.6-7.LP.D
- Define an incline as a sloped surface. P.F.6-7.LP.E
- Engage with inclined planes by exploring the motion a various objects down a slope. P.F.6-7.LP.F

Energy

1 Gravitational Potential Energy P.E.1

Complexity a

a Explain that when two attracting objects are at a distance from each other there is gravitational potential energy present. P.E.1.A

Complexity b

b Describe that the gravitational force between two objects depends on the distance between them and their masses. P.E.1.B

Complexity c

c Identify ways people use energy P.E.1.C

Learning Progression

- Describe that gravitational potential energy exists as a field around attracting objects. As the distance between objects is increased energy is transferred into the field and potential energy increases. As the distance between objects is decreased energy is transferred out of the field and potential energy decreases. P.E.1.LP.A
- Recognize that when two interacting objects are at a distance from one another gravitational potential energy exists. P.E.1.LP.B
- Describe the relationship between distance and gravitational force (closer objects exert more force). P.E.1.LP.C
- Describe the relationship between size and gravitational force (larger objects exert more force). P.E.1.LP.D
- Explain that all objects exert a gravitational force. P.E.1.LP.E

2 Energy in Springs P.E.2

Complexity a

a1 Given a spring stretched various amounts, identify when it has the most potential energy. P.E.2.A1

a2 Identify a real-world scenario where the use of a spring might improve the efficiency or performance of a tool. P.E.2.A2

Complexity b

b1 Compare the distance that two different springs can stretch or can be compressed. P.E.2.B1

b2 Investigate how the use of a spring can improve the efficiency of a tool (e.g., a shock absorber in a car or a ball point pen). P.E.2.B2

Complexity c

c1 Manipulate a variety of springs and make observations (e.g., from inside of a ball point pen, from toys). P.E.2.C1

c2 Identify where springs are used in everyday life. P.E.2.C2

Learning Progression

- Identify a location in the real-world where the addition of a spring could improve the function of a tool. P.E.2.LP.A
- Design a way to use a compressed spring to move an object (e.g., launcher in a pinball machine). P.E.2.LP.B
- Describe that some springs are more easily compressed than others (e.g., investigate various springs). P.E.2.LP.C
- Identify that stretched or compressed springs have elastic potential energy (i.e., can do work). P.E.2.LP.D
- Identify objects that you use in daily activities that contain springs (e.g., beds, cars, pens, toys). P.E.2.LP.E
- Recognize that a coiled material is a spring. P.E.2.LP.F

3 Work and Power P.E.3

Complexity a

a Chart the relationship between work and power. P.E.3.A

Complexity b

b Describe the relationship between work and power (pedaling a bicycle, lifting different weights). More work in a shorter period of time equals more power. P.E.3.B

Complexity c

c Identify work being done. P.E.3.C

Learning Progression

- Compare graphs of work vs. time for two machines or situations. Identify the steeper slope as having more power. P.E.3.LP.A
- Calculate power by dividing the work done by the amount of time needed to do that work. P.E.3.LP.B
- Describe a way to increase the power of a machine (e.g., pedal a bicycle faster because more work is being done during each minute of time). P.E.3.LP.C
- Identify that power is work done per unit of time. P.E.3.LP.D
- Calculate work by multiplying force by the distance moved. P.E.3.LP.E
- Explain that work is done when something is moved a distance by a force (except when the motion and the force are at right angles to each other). P.E.3.LP.F

4 Conservation of Energy P.E.4

Complexity a

a Given situation, describe where the energy has gone (e.g., a car rolling down hill has energy changing from potential to kinetic). P.E.4.A

Complexity b

b Explain that energy changes forms but the total amount is the same before and after a transfer. P.E.4.B

Complexity c

c Identify that energy cannot be created or destroyed. P.E.4.C

Learning Progression

- Given a situation involving energy transfer and/or transformation explain the flow of energy in the system. P.E.4.LP.A
- Identify that when heat is transferred to the air it is not gone, but that it is no longer usable in the system. P.E.4.LP.B
- Explain that the energy from objects slowing down is not disappearing because the friction when two substances move against each other changes kinetic energy to heat which dissipates into the environment. P.E.4.LP.C
- Recognize that heat energy can transfer into the environment around a system (e.g., air) and no longer be noticeable. P.E.4.LP.D
- Explain that friction always changes some energy to heat (e.g., rub hands together to feel heat generated from friction). P.E.4.LP.E
- Describe that there is always the same amount of energy before and after a change. P.E.4.LP.F
- Describe that energy can change form or location but is not created or destroyed (e.g., investigate energy transformations in systems such as electric circuits or balls colliding to see that energy changes location or changes from one form to another, but still exists). P.E.4.LP.G

5 Nuclear Energy P.E.5

Complexity a

a Identify types of nuclear energy (e.g., fission and fusion). P.E.5.A

Complexity b

b Describe ways people use nuclear energy. P.E.5.B

Complexity c

c Identify nuclear energy as a type of energy. P.E.5.C

Learning Progression

- Define nuclear fission as breaking a nucleus and nuclear fusion and combining two nuclei. P.E.5.LP.A
- List some ways humans use nuclear energy (e.g., power submarines, generate electricity, nuclear medicine). P.E.5.LP.B
- Trace or describe the changes nuclear power plants use to capture the energy released when a nucleus breaks apart and use it to generate electricity. P.E.5.LP.C
- Describe that nuclei are being combined in stars (including our sun). P.E.5.LP.D
- Identify that the energy in the nucleus is transferred to a new location when a nucleus is broken or two nuclei are combined. P.E.5.LP.E
- Define nuclear energy as energy stored in the nucleus of an atom. P.E.5.LP.F

Waves

1 Wave Properties • Conservation of energy • Reflection • Refraction • Interference • Diffraction P.W.1

Complexity a

a Compare the speeds at which light waves travel in different mediums. P.W.1.A

Complexity b

b Identify what results from light traveling into a different medium (e.g., dispersion into colors – prism, apparent location of a pencil is different from actual location - water). P.W.1.B

Complexity c

c Identify the reflection of light in a mirror. P.W.1.C

Learning Progression

- Describe the relationship between the medium light is passing through and its speed. Recognize that light travels fastest in a vacuum. P.W.1.LP.A
- Explain why a stick looks crooked in a glass of water. P.W.1.LP.B
- Describe that white light is made of a variety of colors of light (e.g., manipulate prisms to see the separation of white light as it passes from air to glass and back to air). P.W.1.LP.C
- Describe different reflected images (e.g., examine mirrors to see the reflections produced). Compare and contrast the images with the original objects, describing, size, orientation and distance from mirror. P.W.1.LP.D

2 **Light Phenomena • Ray diagrams (propagation of light) • Law of reflection (equal angles) • Snell's law • Diffraction patterns • Wave – particle duality of light • Visible spectrum and color • Visible spectrum and color** P.W.2

Complexity a

a Create a ray diagram showing the path of a light wave. P.W.2.A

Complexity b

b Complete a simple ray diagram to show at what angle a wave is reflected off a surface. P.W.2.B

Complexity c

c Identify a ray diagram. P.W.2.C

Learning Progression

- While observing a light beam interacting with a lens or mirror, construct or select a ray diagram that depicts the observations. P.W.2.LP.A
- Given a partially completed ray diagram showing light passing through a lens fill in the missing ray(s) (could select from a set of options). P.W.2.LP.B
- Given a partially completed ray diagram showing light reflecting off a mirror fill in the missing ray (could select from a set of options). P.W.2.LP.C
- Describe that different lenses affect light in different ways (e.g., investigate the path of light as it passes through a variety of lenses). P.W.2.LP.D
- Identify that light reflects at the same angle it enters a mirror (e.g., shine a laser pointer into a mirror at different angles and see where it reflects). P.W.2.LP.E
- Given a ray diagram, trace the path of light from its source to where it exits the diagram. P.W.2.LP.F
- Recognize that a ray diagram is a way to show the path of light using arrows. P.W.2.LP.G

Electricity and Magnetism

1 Charging Objects (Friction, Contact, and Induction) P.EM.1

Complexity a

a Recognize that charges can transfer from one object to another in different ways. P.EM.1.A

Complexity b

b Understand that objects can have charges which can be either negative or postitive. P.EM.1.B

Complexity c

c Relate the symbols (+, -) to their corresponding charge. P.EM.1.C

Learning Progression

- Give examples of different ways charges can move (e.g., touching a metal surface, feet rubbing on carpet, a static charged balloon held near hair). P.EM.1.LP.A
- Explain that electrons can move from one object to another when they are rubbed together (e.g., rubbing a balloon on hair, rubbing a glass rod with silk) and that one object will end up with a positive charge and the other with a negative charge P.EM.1.LP.B
- Describe that electrons have a negative charge and are located in the outer portions of atoms. P.EM.1.LP.C
- Identify that opposite charges attract each other. P.EM.1.LP.D
- Recognize that a minus sign (-) is used to show a negative charge. P.EM.1.LP.E
- Recognize that a plus sign (+) is used to show a positive charge. P.EM.1.LP.F

2 Coulomb's Law P.EM.2

Learning Progression

Complex and advanced learning standards in Ohio's New Learning Standards are not included in the extended standards.

3 Electric Fields and Electric Potential Energy P.EM.3

Complexity a

a Recognize the effect of an electric field around a positively or negatively charged object (e.g., like charges repel, and opposite charges attract). P.EM.3.A

Complexity b

b Label a model or picture indicating an electric field. P.EM.3.B

Complexity c

c Identify a field as an area around an object. P.EM.3.C

Learning Progression

- Explain that an electric field can exist around an object (e.g., bring a balloon that has been rubbed on hair near small pieces of paper to observe that an electric field exists around the balloon). P.EM.3.LP.A
- Describe how the effect of an electric field varies depending on the charge of the object that enters the field (like charges repel and unlike charges attract). P.EM.3.LP.B
- Recognize that an electric field can cause a change to objects brought into the field (e.g., makes paper shreds move). P.EM.3.LP.C

4 DC Circuits • Ohm's law • Series circuits • Parallel circuits • Mixed circuits • Applying conservation of charge and energy (junction and loop rules) P.EM.4

Complexity a

a Construct a direct current circuit. P.EM.4.A

Complexity b

b Identify the required parts of a circuit. P.EM.4.B

Complexity c

c Complete a direct current circuit (e.g., closing a switch to initiate flow). P.EM.4.C

Learning Progression

- Explain that not all circuits behave exactly alike (e.g., observe the brightness of the bulb in a simple circuit, see how the brightness changes if a second bulb is added in series or in parallel). P.EM.4.LP.A
- Given materials construct a circuit which operates an electric device (e.g., light bulb, motor, buzzer). P.EM.4.LP.B
- Explain that a circuit requires a complete path (closed loop) of conducting materials. P.EM.4.LP.C
- Define materials which transfer electricity easily (metals) as conductors. P.EM.4.LP.D
- Identify the requirements of a complete current circuit. (e.g., observe or construct a circuit with a battery, wires, a bulb and a switch, see what happens as the switch is opened and closed). P.EM.4.LP.E

5 Magnetic Fields P.EM.5

Complexity a

a Apply a real-life example demonstrating the strength of magnetic fields (e.g., explore how many paper clips a weak magnet can hold up versus a strong magnet). P.EM.5.A

Complexity b

b Demonstrate that different magnets have different sized magnetic fields. P.EM.5.B

Complexity c

c Manipulate two objects displaying magnetism. P.EM.5.C

Learning Progression

- Describe that flowing electricity can produce a magnetic field (e.g., electromagnet). P.EM.5.LP.A
- Explain that different magnets produce different magnetic fields (e.g., use paper clips to investigate how far away from a magnet the paperclip can be and still be pulled to the magnet comparing various magnets). P.EM.5.LP.B
- List products in the home that contain magnets (e.g., computers, motors, stud finders, purse clasps, cell phones, refrigerator magnets). P.EM.5.LP.C
- Manipulate a variety of magnets and identify that magnets can have different strengths. P.EM.5.LP.D

6 Electromagnetic Interactions P.EM.6

Learning Progression

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