DOWNLOAD PDF EXPLAINING AND PREDICTING MOTION

Chapter 1 : Forces and Motion: Basics - Force | Motion | Friction - PhET Interactive Simulations

force that opposes motion between two surfaces that are touching projectile object that is thrown or shot near the surface of the earth and that travels in a curved path.

The scientific revolution would change forever how people think about the universe. In his book, Copernicus pointed out that the calculations needed to predict the positions of the planets in the night sky would be somewhat simplified if the Sun , rather than the Earth, were taken to be the centre of the universe by which he meant what is now called the solar system. To the casual observer, the Earth certainly seems to be solidly at rest. Scholarly thought about the universe in the centuries before Copernicus was largely dominated by the philosophy of Plato and Aristotle. According to Aristotelian science, the Earth was the centre of the universe. The four elementsâ€”earth, water, air, and fireâ€”were naturally disposed in concentric spheres, with earth at the centre, surrounded respectively by water, air, and fire. Outside these were the crystal spheres on which the heavenly bodies rotated. Heavy, earthy objects fell because they sought their natural place. Smoke would rise through air, and bubbles through water for the same reason. These were natural motions. All other kinds of motion were violent motion and required a proximate cause. For example, an oxcart would not move without the help of an ox. When Copernicus displaced the Earth from the centre of the universe, he tore the heart out of Aristotelian mechanics, but he did not suggest how it might be replaced. Without suitable explanation, Copernicanism was a violation not only of Aristotelian philosophy but also of plain common sense. The solution to the problem was discovered by the Italian mathematician and scientist Galileo Galilei. Inventing experimental physics as he went along, Galileo studied the motion of balls rolling on inclined planes. He noticed that, if a ball rolled down one plane and up another, it would seek to regain its initial height above the ground, regardless of the inclines of the two planes. That meant, he reasoned, that, if the second plane were not inclined at all but were horizontal instead, the ball, unable to regain its original height, would keep rolling forever. From this observation he deduced that bodies do not need a proximate cause to stay in motion. Instead, a body moving in the horizontal direction would tend to stay in motion unless something interfered with it. Timing the rate of descent of the balls by means of precision water clocks and other ingenious contrivances and imagining what would happen if experiments could be carried out in the absence of air resistance, he deduced that freely falling bodies would be uniformly accelerated at a rate independent of their mass. Moreover, he understood that the motion of any projectile was the consequence of simultaneous and independent inertial motion in the horizontal direction and falling motion in the vertical direction. In his book Dialogues Concerning the Two New Sciences , Galileo wrote, It has been observed that missiles and projectiles describe a curved path of some sort; however, no one has pointed out the fact that this path is a parabola. But this and other facts, not few in number or less worth knowing, I have succeeded in proving. His studies fall into the branch of classical mechanics known as kinematics , or the description of motion. Although Galileo and others tried to formulate explanations of the causes of motion, the focus of the field termed dynamics , none would succeed before Newton. What he saw there, particularly the moons of Jupiter, either prompted or confirmed his embrace of the Copernican system. At the time, Copernicus had few other followers in Europe. Among those few, however, was the brilliant German astronomer and mathematician Johannes Kepler. Kepler devoted much of his scientific career to elucidating the Copernican system. Although Copernicus had put the Sun at the centre of the solar system, his astronomy was still rooted in the Platonic ideal of circular motion. Before Copernicus, astronomers had tried to account for the observed motions of heavenly bodies by imagining that they rotated on crystal spheres centred on the Earth. This picture worked well enough for the stars but not for the planets. This system of astronomy culminated with the Almagest of Ptolemy , who worked in Alexandria in the 2nd century ad. Kepler set out to find further simplifications that would help to establish the validity of the Copernican system. In the course of his investigations, Kepler discovered the three laws of planetary motion that are still named for him. This observation swept epicycles out of astronomy. His second law stated that, as the planet moved through its orbit , a line joining it to the Sun would sweep out equal areas in equal times. For Kepler, this law was merely a rule that helped him make precise calculations for his astronomical tables. Later, however, it would be understood to be a direct consequence of the law of conservation of angular momentum. In particular, the square of the period is proportional to the cube of the semimajor axis of its elliptical orbit. This observation would suggest to Newton the inverse-square law of universal gravitational attraction. Newton is thought to have made many of his great discoveries at the age of 23, when in â€”66 he retreated from the University of Cambridge to his Lincolnshire home to escape from the bubonic plague. However, he chose not to publish his results until the Principia emerged 20 years later. In the Principia, Newton set out his basic postulates concerning force, mass, and motion. In addition to these, he introduced the universal force of gravity , which, acting instantaneously through space, attracted every bit of matter in the universe to every other bit of matter, with a strength proportional to their masses and inversely proportional to the square of the distance between them. The way it worked is what is now referred to as classical mechanics. Fundamental concepts Units and dimensions Quantities have both dimensions, which are an expression of their fundamental nature, and units , which are chosen by convention to express magnitude or size. For example, a series of events have a certain duration in time. Time is the dimension of the duration. The duration might be expressed as 30 minutes or as half an hour. Minutes and hours are among the units in which time may be expressed. One can compare quantities of the same dimensions, even if they are expressed in different units an hour is longer than a minute. Quantities of different dimensions cannot be compared with one another. The fundamental dimensions used in mechanics are time, mass, and length. Symbolically, these are written as t, m, and l, respectively. The study of electromagnetism adds an additional fundamental dimension, electric charge , or q. Other quantities have dimensions compounded of these. Some quantities, such as temperature, have units but are not compounded of fundamental dimensions. Dimensionless numbers may be constructed as ratios of quantities having the same dimension. Dimensionless numbers have the advantage that they are always the same, regardless of what set of units is being used. Governments have traditionally been responsible for establishing and enforcing standard units for the sake of orderly commerce, navigation , science, and, of course, taxation. Today all such units are established by international treaty, revised every few years in light of scientific findings. They are based on the metric system , first adopted officially by France in Other units, such as those of the British engineering system , are still in use in some places, but these are now defined in terms of the SI units. The fundamental unit of length is the metre. By contrast, in the British system, units of length have a clear human bias: Each of these is today defined as some fraction or multiple of a metre one yard is nearly equal to one metre. Times longer than one second are expressed in the units seconds, minutes, hours, days, weeks, and years. The fundamental unit of time i. Units of mass are also defined in a way that is technically sound , but in common usage they are the subject of some confusion because they are easily confused with units of weight , which is a different physical quantity. Thus, the mass of a given object is the same everywhere, but its weight varies slightly if it is moved about the surface of the Earth, and it would change a great deal if it were moved to the surface of another planet. The kilogram is equal to 1, grams; 1 gram is the mass of 1 cubic centimetre of waterâ€”under appropriate conditions of temperature and pressure. Vectors The equations of mechanics are typically written in terms of Cartesian coordinates. At a certain time t, the position of a particle may be specified by giving its coordinates x t , y t , and z t in a particular Cartesian frame of reference. That is, both observers see the same particle executing the same motion and obeying the same laws, but they describe the situation with different equations. This awkward situation may be avoided by means of a mathematical construction called a vector. Although vectors are mathematically simple and extremely useful in discussing mechanics, they were not developed in their modern form until late in the 19th century, when J. Willard Gibbs and Oliver Heaviside of the United States and Britain, respectively each applied vector analysis in order to help express the new laws of electromagnetism proposed by James Clerk Maxwell. A vector is a quantity that has both magnitude and direction. It is typically represented symbolically by an arrow in the proper direction, whose length is proportional to the magnitude of the vector. Although a vector has magnitude and direction, it does not have position. A vector is not altered if it is displaced parallel to itself as long as its length is not changed. By contrast to a vector, an ordinary quantity having magnitude but not direction is known as a scalar. In printed works vectors are often represented by boldface letters such as A or X, and scalars are represented by lightface letters, A or X. The magnitude of a vector, denoted A , is itself a scalarâ€"i. Because vectors are different from ordinary i. Addition, subtraction, three kinds of multiplication, and differentiation will be discussed here. There is no mathematical operation that corresponds to division by a vector. The operation is performed by displacing B so that it begins where A ends, as shown in Figure 1A. C is then the vector that starts where A begins and ends where B ends. There do exist quantities having magnitude and direction that do not obey this requirement. An example is finite rotations in space. Two finite rotations of a body about different axes do not necessarily result in the same orientation if performed in the opposite order. The idea is illustrated in Figure 1B. A vector may be multiplied by a scalar. Thus, for example, the vector 2A has the same direction as A but is twice as long. If the scalar has dimensions, the resulting vector still has the same direction as the original one, but the two cannot be compared in magnitude. The vector v has been multiplied by the scalar t to give a new vector, s, which has the same direction as v but cannot be compared to v in magnitude a displacement of one metre is neither bigger nor smaller than a velocity of one metre per second.

DOWNLOAD PDF EXPLAINING AND PREDICTING MOTION

Chapter 2 : Force and Motion: Facts (Science Trek: Idaho Public Television)

The video introduces Newton's Laws of Motion. This is a good departure point for discussion about the nature of science concept: scientific models, laws, mechanisms, and theories explain natural phenomena.

Interactions of an object with another object can be explained and predicted using the concept of forces, which can cause a change in motion of one or both of the interacting objects. An individual force acts on one particular object and is described by its strength and direction. The strengths of forces can be measured and their values compared. What happens when a force is applied to an object depends not only on that force but also on all the other forces acting on that object. A static object typically has multiple forces acting on it, but they sum to zero. If the total vector sum force on an object is not zero, however, its motion will change. Sometimes forces on an object can also change its shape or orientation. But at speeds close to the speed of light, the second law is not applicable without modification. Nor does it apply to objects at the molecular, atomic, and subatomic scales, or to an object whose mass is changing at the same time as its speed. An understanding of the forces between objects is important for describing how their motions change, as well as for predicting stability or instability in systems at any scale. Page Share Cite Suggested Citation: Disciplinary Core Ideas - Physical Sciences. A Framework for K Science Education: Practices, Crosscutting Concepts, and Core Ideas. The National Academies Press. For any system of interacting objects, the total momentum within the system changes only due to transfer of momentum into or out of the system, either because of external forces acting on the system or because of matter flows. Within an isolated system of interacting objects, any change in momentum of one object is balanced by an equal and oppositely directed change in the total momentum of the other objects. Thus total momentum is a conserved quantity. Grade Band Endpoints for PS2. A By the end of grade 2. Objects pull or push each other when they collide or are connected. Pushes and pulls can have different strengths and directions. Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. By the end of grade 5. Each force acts on one particular object and has both a strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Qualitative and conceptual, but not quantitative addition of forces are used at this level. Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed. By the end of grade 8. The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. Forces on an object can also change its shape or orientation. All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame Page Share Cite Suggested Citation: In order to share information with other people, these choices must also be shared. By the end of grade No details of quantum physics or relativity are included at this grade level. Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. In any system, total momentum is always conserved. 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 the system. All forces between objects arise from a few types of interactions: Collisions between objects involve forces between them that can change their motion. Any two objects in contact also exert forces on each other that are electromagnetic in origin. Gravitational, electric, and magnetic forces between a pair of objects do not require that they be in contact. These forces are explained by force fields that contain energy and can transfer energy through space. These fields can be mapped by their effect on a test object mass, charge, or magnet, respectively. Objects with mass are sources of gravitational fields and are affected by the gravitational fields of all other objects with mass. Gravitational forces are always attractive. For two human-scale objects, these forces are too small to observe without sensitive instrumentation. Gravitational interactions are nonnegligible, however, when very massive objects are involved. These long-range gravitational interactions govern the evolution and Page Share Cite Suggested Citation: Electric forces and magnetic forces are different aspects of a single electromagnetic interaction. Such forces can be attractive or repulsive, depending on the relative sign of the electric charges involved, the direction of current flow, and the orientation of magnets. All objects with electrical charge or magnetization are sources of electric or magnetic fields and can be affected by the electric or magnetic fields of other such objects. Attraction and repulsion of electric charges at the atomic scale explain the structure, properties, and transformations of matter and the contact forces between material objects link to PS1. The strong and weak nuclear interactions are important inside atomic nuclei. These short-range interactions determine nuclear sizes, stability, and rates of radioactive decay see PS1. B By the end of grade 2. When objects touch or collide, they push on one another and can change motion or shape. Objects in contact exert forces on each other friction, elastic pushes and pulls. Electric, magnetic, and gravitational forces between a pair of objects do not require that the objects be in contactâ€"for example, magnets push or pull at a distance. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other. Electric and magnetic electromagnetic forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the Page Share Cite Suggested Citation: There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large massâ€"for example, Earth and the sun. Long-range gravitational interactions govern the evolution and maintenance of large-scale systems in space, such as galaxies or the solar system, and determine the patterns of motion within those structures. Forces that act at a distance gravitational, electric, and magnetic can be explained by force fields that extend through space and can be mapped by their effect on a test object a ball, a charged object, or a magnet, respectively. Forces at a distance are explained by fields permeating space that can transfer energy through space. Magnets or changing electric fields cause magnetic fields; electric charges or changing magnetic fields cause electric fields. Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. The strong and weak nuclear interactions are important inside atomic nucleiâ€"for example, they determine the patterns of which nuclear isotopes are stable and what kind of decays occur for unstable ones. Events and processes in a system typically involve multiple interactions occurring simultaneously or in sequence. A stable system is one in which the internal and external forces are such that any small change results in forces that return the system to its prior state e. A system can be static but unstable, with any small change leading to forces that tend to increase that change e. And a stable system can appear to be unchanging when flows or processes within it are going on at opposite but equal rates e. Stability and instability in any system depend on the balance of competing effects. A steady state of a complex system can be maintained through a set of feedback mechanisms, but changes in conditions can move the system out of its range of stability e. With no energy inputs, a system starting out in an unstable state will continue to change until it reaches a stable configuration e. Viewed at a given scale, stable systems may appear static or dynamic. Conditions and properties of the objects within a system affect the rates of energy transfer and thus how fast or slowly a process occurs e. When a system has a great number of component pieces, one may not be able to predict much about its precise future. For such systems e. C By the end of grade 2. Whether an object stays still or moves often depends on the effects of multiple pushes and pulls on it e. It is useful to investigate what pushes and pulls keep something in place e. A system can change as it moves in one direction e. A system can appear to be unchanging when processes within the system are occurring at opposite but equal rates e. Changes can happen very quickly or very slowly and are sometimes hard to see e. Conditions and properties of the objects within a system affect how fast or slowly a process occurs e. A stable system is one in which any small change results in forces that return the system to its prior state e. A system can be static but unstable e. Many systems, both natural and engineered, rely on feedback mechanisms to maintain stability, but they can function only within a limited range of conditions. Systems often change in predictable ways; understanding the forces that drive the transformations and cycles within a system, as well as the forces imposed on the system from the outside, helps predict its behavior under a variety of conditions. Systems may evolve in unpredictable ways when the outcome depends sensitively on the starting condition and the starting condition cannot be specified precisely enough to distinguish between different possible outcomes.

DOWNLOAD PDF EXPLAINING AND PREDICTING MOTION

Interactions of objects can be explained and predicted using the concept of transfer of energy from one object or system of objects to another. The total energy within a defined system changes only by the transfer of energy into or out of the system. At the macroscopic scale, energy manifests itself in multiple phenomena, such as motion, light, sound, electrical and magnetic fields, and thermal energy. Historically, different units were introduced for the energy present in these different phenomena, and it took some time before the relationships among them were recognized. Energy is best understood at the microscopic scale, at which it can be modeled as either motions of particles or as stored in force fields electric, magnetic, gravitational that mediate interactions between particles. This last concept includes electromagnetic radiation, a phenomenon in which energy stored in fields moves across space light, radio waves with no supporting matter medium.

DOWNLOAD PDF EXPLAINING AND PREDICTING MOTION

Chapter 3 : Forces and Motion - Force | Position | Velocity - PhET Interactive Simulations

But Newton's laws can't explain the differences in motion, mass, distance, and time that result when objects are observed from two very different frames of reference. To describe motion in these situations, scientists must rely on Einstein's theory of relativity.

Engage 15 minutes No! By using demonstrations, research and art, students participate actively in this introductory lesson to the laws of motion PS2. In addition to addressing forces and motion disciplinary core ideas, rigor is added in terms of the science practices. Why is a picture said to be worth 1, words? After viewing the, "If a picture is worth 1, words" meme, students enthusiastically respond, "Yeah! Some probing questions that can help the discussion develop are: What can a picture do that words cannot? When are pictures better to use than words? When might you want to use pictures in science to help you explain what you are thinking? These questions may lead to a connection to the models cross-cutting concept. Students then view the following picture with the instructions to choose five words that this picture evokes for them. This picture has powerful connotations that students share. To finish the ENGAGE portion of the lesson, students view the following picture with the instructions to choose five words that this picture evokes for them. Drawing on previous discussions about the power of pictures, we discuss what "graffiti notes" might look like and what types of information to include. Once students understand the concept of graffiti notes splash words and pictures on the page using colors and symbols to build memorable visual displays , students activate or build background knowledge by viewing the Sir Isaac Newton BrainPop video. This is a good departure point for discussion about the nature of science concept: For a brief explanation of scientific theories, hypotheses and laws, click here. For each law, students follow this pattern slides 2 - 4: Predict â€” Observe - Explain Protocol. Predict - Observe - Explain: A Protocol for Demonstrations. Once we have completed this cycle for each law, students spend time enhancing their graffiti notes using the following criteria slide 5 and by adding artistic components:

Chapter 4 : Sixth grade Lesson Newton's Laws Graffiti | BetterLesson

PGC: Observe, explain, and predict natural phenomena governed by Newton's laws of motion, acknowledging the limitations of their application to very small or very fast objects.

Normal Force A book resting on a table has the force of gravity pulling it toward the Earth. But the book is not moving or accelerating, so there must be opposing forces acting on the book. This force is caused by the table and is known as the normal force. If you place a thin piece of wood or plastic a ruler works so that it is supported by both ends by books perhaps and place a small heavy object in the center, the piece of wood will bend. Of course it wants to straighten out so it exerts an upward force on the object. This upward force is the normal force. You can feel the force yourself if you push down in the center of the piece of wood. The harder you push, the more the wood bends and the harder it pushes back. Applied Force Applied force refers to a force that is applied to an object such as when a person moves a piece of furniture across the room or pushes a button on the remote control. A force is applied. Frictional Force Frictional force is the force caused by two surfaces that come into contact with each other. Friction can be helpful as in the friction that allows a person to walk across the ground without sliding or it can be destructive such as the friction of moving parts in a motor that rub together over long periods of time. Tension Force Tension force is the force applied to a cable or wire that is anchored on opposite ends to opposing walls or other objects. This causes a force that pulls equally in both directions. Spring Force The spring force is the force created by a compressed or stretched spring. Depending upon how the spring is attached, it can pull or push in order to create a force. Resisting Forces Resisting force , like air resistance or friction, change motion. Whether the forces actually stop or slow something depends upon your point of view. Air friction makes a leaf travel along in the wind. In each case, the friction makes the two things like the air and the leaf move together. Inertia is actually not a force at all, but rather a property that all things have due to the fact that they have mass. The more mass something has the more inertia it has. You can think of inertia as a property that makes it hard to push something around. Friction is a force that happens when objects rub against one another. Say you were pushing a toy train across the floor. Now say you try to push a real train. The heavier the object, the stronger the force of friction. Velocity Velocity is the speed of an object in one direction. If an object turns a corner, it changes its velocity because it is no longer moving in its original direction. According to a story, Newton saw an apple fall to the ground and he figured out that the same force which caused the apple to fall also governed the motion of the Moon and the planets. A body in motion tends to remain in motion, a body at rest tends to remain at rest unless acted on by an outside force. So, if an object is moving â€" its inertia mass will tend to keep it in motion, and if something is at rest, its inertia will tend to keep it at rest. From the Goddard Space Center: Check out these additional ideas. If your basketball goes rolling into the street and is hit by a bike, either the ball will change direction or its speed or both. It will also be true for the bike. Here are some additional ideas. It states that for every force and action, there is an equal and opposite reaction. This is what causes a cannon to recoil when it fires. Click on a Topic:

Chapter 5 : Open Course : Astronomy : Introduction : Lecture 6 : Laws of Motion & Gravity

These four interactions determine changes in particle motion. If force is acted on an object, then its motion is going to change from what it was before the force acted.

History[edit] Historically, equations of motion first appeared in classical mechanics to describe the motion of massive objects , a notable application was to celestial mechanics to predict the motion of the planets as if they orbit like clockwork this was how Neptune was predicted before its discovery , and also investigate the stability of the solar system. It is important to observe that the huge body of work involving kinematics, dynamics and the mathematical models of the universe developed in baby steps â€" faltering, getting up and correcting itself â€" over three millennia and included contributions of both known names and others who have since faded from the annals of history. In antiquity, notwithstanding the success of priests , astrologers and astronomers in predicting solar and lunar eclipses , the solstices and the equinoxes of the Sun and the period of the Moon , there was nothing other than a set of algorithms to help them. Despite the great strides made in the development of geometry made by Ancient Greeks and surveys in Rome, we were to wait for another thousand years before the first equations of motion arrive. The exposure of Europe to Arabic numerals and their ease in computations encouraged first the scholars to learn them and then the merchants and invigorated the spread of knowledge throughout Europe. By the 13th century the universities of Oxford and Paris had come up, and the scholars were now studying mathematics and philosophy with lesser worries about mundane chores of lifeâ€"the fields were not as clearly demarcated as they are in the modern times. Of these, compendia and redactions, such as those of Johannes Campanus , of Euclid and Aristotle, confronted scholars with ideas about infinity and the ratio theory of elements as a means of expressing relations between various quantities involved with moving bodies. These studies led to a new body of knowledge that is now known as physics. Of these institutes Merton College sheltered a group of scholars devoted to natural science, mainly physics, astronomy and mathematics, of similar in stature to the intellectuals at the University of Paris. Thomas Bradwardine , one of those scholars, extended Aristotelian quantities such as distance and velocity, and assigned intensity and extension to them. Bradwardine suggested an exponential law involving force, resistance, distance, velocity and time. The Merton school proved that the quantity of motion of a body undergoing a uniformly accelerated motion is equal to the quantity of a uniform motion at the speed achieved halfway through the accelerated motion. For writers on kinematics before Galileo , since small time intervals could not be measured, the affinity between time and motion was obscure. They used time as a function of distance, and in free fall, greater velocity as a result of greater elevation. Discourses such as these spread throughout Europe and definitely influenced Galileo and others, and helped in laying the foundation of kinematics. The relationships between speed, distance, time and acceleration was not known at the time. Galileo was the first to show that the path of a projectile is a parabola. Galileo had an understanding of centrifugal force and gave a correct definition of momentum. This emphasis of momentum as a fundamental quantity in dynamics is of prime importance. He measured momentum by the product of velocity and weight; mass is a later concept, developed by Huygens and Newton. In the swinging of a simple pendulum, Galileo says in Discourses [6] that "every momentum acquired in the descent along an arc is equal to that which causes the same moving body to ascend through the same arc. The term "inertia" was used by Kepler who applied it to bodies at rest. The first law of motion is now often called the law of inertia. Galileo did not fully grasp the third law of motion, the law of the equality of action and reaction, though he corrected some errors of Aristotle. With Stevin and others Galileo also wrote on statics. He formulated the principle of the parallelogram of forces, but he did not fully recognize its scope. Galileo also was interested by the laws of the pendulum, his first observations of which were as a young man. In , while he was praying in the cathedral at Pisa, his attention was arrested by the motion of the great lamp lighted and left swinging, referencing his own pulse for time keeping. To him the period appeared the same, even after the motion had greatly diminished, discovering the isochronism of the pendulum. More careful experiments carried out by him later, and described in his Discourses, revealed the period of oscillation varies with the square root of length but is independent of the mass the pendulum. Later the equations of motion also appeared in electrodynamics , when describing the motion of charged particles in electric and magnetic fields, the Lorentz force is the general equation which serves as the definition of what is meant by an electric field and magnetic field. With the advent of special relativity and general relativity , the theoretical modifications to spacetime meant the classical equations of motion were also modified to account for the finite speed of light , and curvature of spacetime. There are analogs of equations of motion in other areas of physics, for collections of physical phenomena that can be considered waves, fluids, or fields. Kinematic equations for one particle[edit] Kinematic quantities[edit] Kinematic quantities of a classical particle of mass m:

DOWNLOAD PDF EXPLAINING AND PREDICTING MOTION

Chapter 6 : Equations of motion - Wikipedia

How can one predict an object's continued motion, changes in motion, or stability? Interactions of an object with another object can be explained and predicted using the concept of forces, which can cause a change in motion of one or both of the interacting objects.

Jon Hayden sanders 1 Share to: There are threelaws that were compiled by Issac Newton, who was a mathematician. What are the four fundamental forces of nature? The four forces affecting matter are in order of increasing strength: Weak Nuclear Force 4. Strong Nuclear Force â€¦ Gravity holds macroscopic matter together. Electromagnetic force prevents atoms and molecules from getting too close, or from passing through each other. The weak force is why molecules form. What are the four fundamental forces? The four fundamental forces or interactions of the Universe, in sort of 1 increasing strength, are: Force of attraction between objects with mass. The strenâ€¦gth of the gravitational force is proportional to the mass of the physical bodies and inversely proportional to the square of the distance, and is the only force that works over long distances. Also called the weak nuclear force; it is caused by the exchange of W and Z bosons, the best known effect being beta decay. The interaction between particles that have electric charges and is found in electric and magnetic fields. Residual binding energy, also called the nuclear force , i. For instance, one could say that gravity is the strongest force because it works over the greatest distance, but within the confines of the nucleus, the stated order is generally 2 as stated. As a result, in nuclei of atomic number 82 lead and smaller, the Strong Interaction wins out, but for nuclei of atomic number 83 bismuth and larger, Electromagnetism starts to overcome the Strong Interaction, making all of the larger nuclei unstable 3 , i. Technetium and promethium, while smaller than lead, have no stable isotopes. Carbon is stable, while carbon is not. These are just examples. This instability, even with the Strong Interaction being more powerful than Electromagnetism, is due to the Weak Interaction, along with the possibility that every isotope with atomic number greater than 40 zirconium is theoretically possible of spontaneous fission. Although some have not yet be observed. The strong nuclear force, the weak nuclear force, electromagnetism, and gravity.

Chapter 7 : How are the four fundamental forces in physics important in explaining and predicting motion

motion (Newton's Second Law), frame of reference, and specification of units.] [Assessment Boundary: Assessment is limited to forces and changes in motion in one- dimension in an inertial reference frame and to change in one variable at a time.

God said, "Let Newton be! As is often the case in science, however, this explanation immediately lead to additional, more basic questions: Why are the orbits elliptical? Why is the Sun at one focus? Why do the planets move faster at perihelion? These questions were addressed by the English scientist and mathematician Isaac Newton - Newton had a fundamental belief that guided his work: In other words, by understanding why objects move the way they do here on Earth, we should also be able to understand the motions of the planets. Newton therefore studied motion in detail, making many new observations. Newton formulated his new observations as well as those of others in three fundamental Laws of Motion which govern all objects, including the planets. When Newton talked about the motion of an object, he was referring to two general characteristics: Together, these are also known as the linear momentum of the object. An object at rest is simply a special case of motion, with zero speed. The motion of an object will remain unchanged unless a force acts on it. In other words, an object will never change its speed or direction unless something comes along and forces it to do so. This is an example of the principle of Conservation of Linear Momentum. However, the First Law was in direct contradiction to the still-dominant teachings of Aristotle, who thought that all objects in motion will eventually come to rest of their own accord. Newton therefore felt it necessary to make a forceful contradiction. Like motion, force has both a value or "strength", and a direction in which it acts. We commonly think of "acceleration" as a speeding up, but in physics it can also include a slowing down "deceleration" as well as a change in direction. In the metric system, the unit of force is called a Newton, whose abbreviation is "N". In the English system, the unit of force is the pound; it is equal to 4. For example, the larger the force is, the larger the acceleration: Second, the Second Law actually includes the First Law within it. Third, for an equal force, a larger mass must have a smaller acceleration, and vice versa: In other words, a larger mass has greater inertia than a smaller mass. The force on an object is always due to another object, and that other object always feels an equal and opposite force. You are familiar with this law from striking an object with your hand: Gravity holds the Sun and planets together in the solar system, and holds stars together in galaxies. You should be personally familiar with the effects of gravity, which holds you to the Earth and in general makes things "fall down". We will discuss the gravitational force in more detail below. Electromagnetism holds atoms together, makes compasses point north, and is the source of starlight and auroras. You should also be personally familiar with electromagnetism, via common devices such as electric appliances, refrigerator magnets, and the innumerable sources of light surrounding you. We will discuss electromagnetism in more detail later on, in the contexts of electricity , magnetism , and light. The strong nuclear force holds atomic nuclei together, and we will talk about it more in that context. The strong nuclear force is involved in the generation of energy in stars and in their explosive destruction known as type I supernovae. Although this is probably not a force with which you have personal familiarity, it has been harnessed in nuclear power plants to provide electricity, and in various medical applications. The weak nuclear force can change one type of subatomic particle into another in some situations such as radioactive decay , the generation of energy in stars , and in type II supernovae. The weak nuclear force shows up in the same sorts of technologies described above for the strong nuclear force. We will consider the weak nuclear force in more detail in our discussion of radioactive decay. You are also personally familiar with contact forces, the result of electromagnetic forces acting within solids, liquids, and gasses: The normal force prevents planets and stars from collapsing down to zero size under the force of their own gravity though not always! Cohesion prevents moons and planets from being torn apart by tidal forces though not always! Friction between molecules in a gas falling into a black hole will cause it to heat up and emit radiation. Here, G is a constant, M and m are two masses, and r is the separation between them. Therefore, large masses are required to provide an appreciable force, e. In the process Newton also had to invent the mathematics of calculus! Because the Sun is so much more massive than any of the planets, it has a very small gravitational acceleration, and can be taken as essentially motionless. Objects with circular and elliptical orbits move around the Sun with a definite period, always between their perihelion and aphelion distances, and sweeping out equal areas in equal times. As before, a is measured in AU and P is measured in years. But now the mass M appears, and here is measured as multiples of the mass of the Sun. This result provides a powerful tool for determining the mass of the Sun, as well any planet being orbited by a moon, simply by measuring a and P. Newton could immediately calculate the mass of which planets? Circular and elliptical orbits describe objects which are bound to the Sun. Newton also demonstrated that there could be parabolic and hyperbolic orbits! A parabolic orbit describes an object which is marginally bound. An object in a hyperbolic orbit travels in a straight line until it nears the Sun and has its path deflected by gravity. Such an object is not part of our solar system, but is instead simply passing through, and can be infinitely far from the Sun while still moving at high speed. An object with a hyperbolic orbit is therefore said to be unbound. We all have an intuitive idea of what this means. For example, when something moves very fast we say it "has a lot of energy". We might also recognize that heat, electricity, and light have energy as well. Energy of motion is called kinetic energy. For example, a car travelling at 90 mph has much more energy than a baseball travelling at 90 mph. In the metric system, the unit of energy is the Joule, whose abbreviation is "J". A unit of energy you may be more familiar with is the food calorie, which is equal to J. You are probably more familiar with power, the rate of energy production or use energy per unit time. The metric unit of power is called a Watt, whose abbreviation is "W". If the object is thrown upward, it will have some initial speed but it will immediately begin to slow down and eventually stop, i. The object will then begin to move back downward, rapidly gaining speed as it is accelerated by gravity, and its kinetic energy increases. We intuitively think of an object with greater height as having, "potentially", more energy, because it will be moving faster when it reaches us. If kinetic energy increases, potential energy must decrease by an equal amount, and vice versa, so that E remains a constant value. We can think of this as one kind of energy being converted into another. The potential energy described above is basically another way to characterize the force of gravity. We can define potential energy for all of the fundamental forces, in such a way that energy is, in general, conserved. As a result, energy conservation and conversion from one form to another are extremely important concepts in physics and astronomy, and we will see many applications, such as planet formation and solar thermal equilibrium. Note that the potential energy is always a negative number, and reaches its maximum value of zero when the two masses are an infinite distance r apart. For planetary orbits, we can take the Sun to be fixed at position zero, and a planet to be a distance r away from it. With each orbit around the Sun, the planet will move between its perihelion and its aphelion , and as it does so its energy will convert back and forth between potential and kinetic. At perihelion, kinetic energy is a maximum and potential energy is a minimum; at aphelion, kinetic energy is a minimum and potential energy is a maximum. This is true for all bound objects those in circular or elliptical orbits. You can further explore planetary motion and energy using this Java applet. We can get an intuitive feel for potential energy by "revolving" the potential energy curve into three dimensions. Potential energy then forms a two-dimensional surface called a gravity well, with the Sun at the bottom and planetary orbits forming curves along it. Imagine walking around the edge of a valley: This means that the object must be marginally bound or unbound, and so have at least zero total energy: Newton knew about escape velocity, and used the idea in his Mathematical Principles to illustrate how gravity works; you can explore this yourself with this Java applet from the University of Virginia. Much like linear momentum , objects have a tendency to keep rotating in the absence of external forces. This "rotational inertia " is characterized by angular momentum, which can be loosely defined as: The "direction" of angular momentum is also important; two rotating objects with the same mass and speed, but different axes of rotation, have different angular momenta. For many forces, including gravity, the angular momentum of a rotating or revolving object will be conserved, i. Conservation of angular momentum is why the Earth always rotates once every 24 hours, and why its rotation axis remains relatively fixed in space as it orbits the Sun. Halley noticed that the comets of , , and had similar characteristics, and were separated by the same period of 76 years. In , Halley visited Newton in Cambridge, and told him about his suspicion that they were the same comet moving in a periodic orbit around the Sun. In , an amateur astronomer named William Herschel , who had built one of the most powerful telescopes of the time, noticed "a curious either nebulous star or perhaps a comet". Subsequent observations revealed that this object moved relative to the stars, although more slowly than a comet. Herschel soon realized that he had discovered a seventh planet, Uranus and the first in recorded history! At its brightest, Uranus is barely visible to the naked eye in a dark sky. Because of its slow motion, however, Uranus was always mistaken for a star by earlier observers. Neptune moves even more slowly than Uranus, and it has an orbital period of years.

DOWNLOAD PDF EXPLAINING AND PREDICTING MOTION

Chapter 8 : Mechanics | physics | www.nxgvision.com

Chapter 2: Forces 61 NewtonÃ•s three laws describe and predict motion. NewtonÃ•s three laws can explain the motion of almost any object, including the motion of www.nxgvision.com illustrations on page 60 show.

From this equation one can derive the equation of motion for a varying mass system, for example, the Tsiolkovsky rocket equation. The first skater on the left exerts a normal force N12 on the second skater directed towards the right, and the second skater exerts a normal force N21 on the first skater directed towards the left. The third law states that all forces between two objects exist in equal magnitude and opposite direction: In some situations, the magnitude and direction of the forces are determined entirely by one of the two bodies, say Body A; the force exerted by Body A on Body B is called the "action", and the force exerted by Body B on Body A is called the "reaction". This law is sometimes referred to as the action-reaction law , with FA called the "action" and FB the "reaction". The action and the reaction are simultaneous, and it does not matter which is called the action and which is called reaction; both forces are part of a single interaction, and neither force exists without the other. Similarly, the tires of a car push against the road while the road pushes back on the tiresâ€”the tires and road simultaneously push against each other. In swimming, a person interacts with the water, pushing the water backward, while the water simultaneously pushes the person forwardâ€”both the person and the water push against each other. The reaction forces account for the motion in these examples. These forces depend on friction; a person or car on ice, for example, may be unable to exert the action force to produce the needed reaction force. Corpus omne perseverare in statu suo quiescendi vel movendi uniformiter in directum, nisi quatenus a viribus impressis cogitur statum illum mutare. Every body persists in its state of being at rest or of moving uniformly straight forward, except insofar as it is compelled to change its state by force impressed. He thought that a body was in its natural state when it was at rest, and for the body to move in a straight line at a constant speed an external agent was needed continually to propel it, otherwise it would stop moving. Galileo Galilei , however, realised that a force is necessary to change the velocity of a body, i. In other words, Galileo stated that, in the absence of a force, a moving object will continue moving. The tendency of objects to resist changes in motion was what Johannes Kepler had called inertia. This insight was refined by Newton, who made it into his first law, also known as the "law of inertia"â€”no force means no acceleration, and hence the body will maintain its velocity. The law of inertia apparently occurred to several different natural philosophers and scientists independently, including Thomas Hobbes in his Leviathan. Mutationem motus proportionalem esse vi motrici impressae, et fieri secundum lineam rectam qua vis illa imprimitur. The change of momentum of a body is proportional to the impulse impressed on the body, and happens along the straight line on which that impulse is impressed. If a force generates a motion, a double force will generate double the motion, a triple force triple the motion, whether that force be impressed altogether and at once, or gradually and successively. And this motion being always directed the same way with the generating force , if the body moved before, is added to or subtracted from the former motion, according as they directly conspire with or are directly contrary to each other; or obliquely joined, when they are oblique, so as to produce a new motion compounded from the determination of both. To every action there is always opposed an equal reaction: Whatever draws or presses another is as much drawn or pressed by that other. If you press a stone with your finger, the finger is also pressed by the stone. If a horse draws a stone tied to a rope, the horse if I may so say will be equally drawn back towards the stone: If a body impinges upon another, and by its force changes the motion of the other, that body also because of the equality of the mutual pressure will undergo an equal change, in its own motion, toward the contrary part. The changes made by these actions are equal, not in the velocities but in the motions of the bodies; that is to say, if the bodies are not hindered by any other impediments. For, as the motions are equally changed, the changes of the velocities made toward contrary parts are reciprocally proportional to the bodies. This law takes place also in attractions, as will be proved in the next scholium. These three laws hold to a good approximation for macroscopic objects under everyday conditions. Therefore, the laws cannot be used to explain phenomena such as conduction of electricity in a semiconductor , optical properties of substances, errors in non-relativistically corrected GPS systems and superconductivity. Explanation of these phenomena requires more sophisticated physical theories, including general relativity and quantum field theory. This can be stated simply, "Momentum, energy and angular momentum cannot be created or destroyed. The standard model explains in detail how the three fundamental forces known as gauge forces originate out of exchange by virtual particles. Other forces, such as gravity and fermionic degeneracy pressure , also arise from the momentum conservation. Indeed, the conservation of 4-momentum in inertial motion via curved space-time results in what we call gravitational force in general relativity theory. The application of the space derivative which is a momentum operator in quantum mechanics to the overlapping wave functions of a pair of fermions particles with half-integer spin results in shifts of maxima of compound wavefunction away from each other, which is observable as the "repulsion" of the fermions. Newton stated the third law within a world-view that assumed instantaneous action at a distance between material particles. However, he was prepared for philosophical criticism of this action at a distance , and it was in this context that he stated the famous phrase " I feign no hypotheses ". In modern physics, action at a distance has been completely eliminated, except for subtle effects involving quantum entanglement. Despite only being an approximation, in modern engineering and all practical applications involving the motion of vehicles and satellites, the concept of action at a distance is used extensively.

Chapter 9 : Newton's laws of motion - Wikipedia

Force and motion are important parts of everyday life. As students study this unit, they will learn how these physical factors impact their lives and work. The lessons and activities will help students become aware of factors like friction, gravity, and magnetic force.

Materials List To share with the entire class: Or better yet, how hard you need to hit a baseball to get a home run? These are real questions that not only apply to baseball, but other real-life situations including the paths of meteorites and trajectories of rockets. We can even calculate its location at a given time. Why is this important? It is our goal to construct a device that can shoot food down to them. By studying the motion of things traveling in the air, also known as projectiles, we can figure out just how fast the food needs to be launched in order for it to get to them. If we shoot too low, the food will be destroyed and if we shoot too high, we may attract unwanted creatures such as bears. The motion of a projectile, a container of food in this case, traveling through the air is called projectile motion. We see projectile motion in action almost every day. Can you think of any examples in which you have seen projectile motion? The change in velocity with respect to time. A numerical description of how far apart objects are. The branch of mechanics that studies pure motion of an object without consideration of mass. The motion or path of a projectile. A measurement of how long an event or occurrence happens. The distance traveled over a period of time. Procedure Background Figure 1. During a soccer game, a referee often drops the soccer ball from about four or five feet above the ground. Even though the ball falls vertically to the ground, this is still an example of projectile motion. Otherwise, use another means of launching a ball, such as a rubber band or a small catapult. It is also necessary for the instructor to be familiar with kinematics and equations of motion see below and understand the kind of forces that act upon an object in projectile motion. For this activity, we only use gravity acting on the food in the vertical direction, and we assume that the horizontal direction does not experience any forces air resistance is neglected. For example, if a ball is dropped from a height of 4 meters, similar to what is about to happen in Figure 1, how long does it take to reach the ground? This requires using Equation 2 see below and making the initial distance equal to 4 meters and the final distance equal to 0. Solving Equation 2 for t gives you 0. The equations listed below are considered the fundamental equations of motion. The combination of these four equations can solve any projectile motion problem, given the correct number of initial conditions. Equations 1 - 4 for projectile motion. In addition to the kinematic equations for projectile motion, the instructor should review the concepts of kinetic and potential energy with students in the context of this activity. Equations for calculating kinetic and potential energy of a projectile are shown below. Equations to calculate the potential and kinetic energy of a projectile. Prepare LEGO parts and make sure all the pieces required for constructing the launcher are available. A simple sample code is as follows: Pressing one switch switch 2 pitches the cannon up, and pressing the other switch switch 3 pitches the cannon down. Pressing both buttons simultaneously will start the ball-pitching wheels spinning. Adjust power, and conversely, speed at which the ball is launched by just changing the motor power values between Do not over-actuate the pitch legs, as the structure will block their rotation, breaking the gearing system. Describe the path an object traverses in the air. Ask why the path appears the way it does. Explain the terms in Equations and go through an example with students such as the one provided in the background section. Point out that Equations 2 and 3 have a squared term. In general, this means that the changes in velocity and distance as the ball moves are not linear, much like the motion of the ball as it moves in air. Ask students where they have seen examples of projectile motion. Ask why we might want to study it. Write down student ideas on the classroom board for all to see. Describe the real-world importance to students, such as predicting the path or landing of meteors, accuracy in aiming a ball or rocket, or delivering food to hikers. Refer to the Engineering Connection section for a few more examples. Hand out the worksheet with problems, each solving for a different kind of variable, such as time, initial velocity or distance. Review answers with students, ensuring that students can explain why they used certain equations and can explain step by step how to use the equations to solve each problem. See Figure 2 for an example, although the shooter can be constructed in more than one way. Example ball shooter robot. Identify the area to hit as a couple of feet from the base below. Mark the designated target as a circle made of tape. Let students observe the ball launcher setup. Have them measure the vertical distance between the ball release point on the machine and the ground. Then have them shoot balls at a designated spot and measure the horizontal distance traveled by each ball. With this information, they can calculate the initial velocity. You can also have the students drop balls in the beginning to see if their answers were true to the worksheet. Because it is not easy to calculate exact speed by knowing motor power, have students use trial and error when launching balls to the designated area. Once students repeatedly hit the target, they should note the power level. Once calculations are carried out that predict how fast the ball was launched in order to get to the target area, have students identify the power-to-speed relationship. Repeat steps again at another distance. Now students can calculate speed as a function of power. For example, if they hit a target "x" meters away, they calculate the speed at which the ball was launched using equations of motion and note the power level required to produce this initial speed. Then they take their first value of speed and subtract the second. Divide that by the first value of power minus the second value of power to get a relationship between speed and power, shown in Equation 5. The relationship between speed and power. Equation 5 represents speed in terms of the powers and speeds taken from the two measurements. Using this equation, all speeds can be calculated from the power. The last step is to change the target zone one more time and have students measure the distance to it, do the calculations for speed, and plug the correct power number into the code according to the Equation 5. Expect students to hit the target on the first try, which should excite them, knowing that they used math and analysis to predict future performance!