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Gravitational potential energy is the energy stored in a mass due to its position in a gravitational fieldIf a mass is lifted up, it will gain gravitational potential energyIf a mass falls, it will lose gravitational potential energyThe equation for gravitational potential energy when close to the surface of the Earth is:Where:ΔEp = gravitational potential energy (J)m = mass (kg)g = gravitational field strength (9.8 N kg–1)Δh = change in height (m)Gravitational potential energy: The energy an object has when lifted upThe potential energy on the Earth's surface at ground level is usually taken to be equal to zeroHowever, any position can be taken as zero if you are calculating the change in gravitational potential energyThis equation is only relevant for energy changes in a uniform gravitational field (such as near the Earth's surface)A different potential energy is used in the gravitational fields topic, because the field is no longer uniform outside of the Earth's surfaceGravitational Potential Energy vs HeightThe two graphs below show how the gravitational potential energy changes with height for a ball being thrown up in the air and then falling down (ignoring air resistance)Graphs showing the linear relationship between gravitational potential energy and heightSince the graphs are straight lines, gravitational potential energy and height are said to have a linear relationshipThese graphs would be identical for gravitational potential energy against time instead of heightTo get to his apartment a man has to climb five flights of stairs.The height of each flight is 3.7 m and the man has a mass of 74 kg.What is the approximate change in the man's gravitational potential energy during the climb?A. 13 000 J B. 2700 J C. 1500 J D. 12 500 JGravitational potential energy is often shortened to GPE for ease. In your equations, you should stick to the correct symbol, which is Did this page help you? A classic GCSE question discusses the change between GPE and KE for a skydiver. When a person or object falls, GPE is converted to KE. The skydiver has maximum GPE before his jump. He is at his highest point possible, so GPE is 100 and KE is 0. The skydiver accelerates and GPE is converted to KE. As he begins to fall, he loses height and therefore GPE falls, and gains velocity so KE increases. All GPE lost is converted to KE. The skydiver continues to fall and more GPE is converted to KE. As the skydiver falls more and more, GPE continues to be converted to KE. Before he hits the ground, GPE is minimum and KE is maximum. As the skydiver is about to hit the ground, his KE will be at its highest level. As he hits the ground, GPE and KE become zero. All energy is lost as heat and sound. Above, we have assumed that all GPE lost is converted to the KE gained. In reality, some energy will be converted to heat and sound due to friction and air resistance. Linking the KE and GPE Linking the KE and GPE Question: Peter has climbed up his ladder, of height 3m, to put boxes into his attic. However, he drops a box of old books, of mass 10kg, from the top of the ladder, and they fall to hit the ground below. The books initially fell with a velocity of 20 m/s. What is the kinetic energy of the books just before they hit the ground? (Assume the gravitational field strength g is 10 N / kg, and that the effects of friction and air resistance are negligible). Ignore the velocity value, as we don't know the end velocity. The question has given you velocity values to mislead you. Instead we can work out the GPE the box had at its highest point. We can assume all of the GPE energy is transferred to KE, and none lost from the energy transfer due to air resistance and friction. GPE = 10 x 10 x 3 = 300J. Question: Two cars are driving up a mountain. Car A travels up to Flag A (height 30m) whilst Car B travels up to Flag B (height 50m). Both hills have a 1 in 5 slope, meaning that the cars ascend 1m for every 5m travelled along the road. Assuming that both cars have a mass of 50kg and travel at 20 m/s, work out the difference in the distance travelled by each car, the difference in gravitational potential energy at the flag points, and the difference in kinetic energy. Linking the KE and GPE (g = 10 N / kg) Linking the KE and GPE Difference in KEAs we are looking for the difference in KE , the Ek=0.5mv2 formula can be re-written as: Before proceeding with the calculation, we notice that the mass and velocity of the cars is the same. Hence, the difference in kinetic energy is zero! Distance travelled Difference in GPE at Maximum Linking the KE and GPE The correct answer is D. →What is kinetic energy (KE)? Kinetic energy is the energy an object possesses due to its motion. It is the energy an object has because it is moving. →What is gravitational potential energy (GPE)? Gravitational potential energy is the energy an object possesses due to its height and the strength of gravity. It is the energy an object has because of its position in a gravitational field. →How are kinetic energy and gravitational potential energy related? Kinetic energy and gravitational potential energy are related because they are both forms of energy that an object can possess. When an object falls, its GPE decreases as it gains KE. Conversely, when an object rises, it gains GPE as its KE decreases. →What is the equation for kinetic energy? The equation for kinetic energy is KE = 0.5mv^2, where m is the mass of the object and v is its velocity. →What is the equation for gravitational potential energy? The equation for gravitational potential energy is GPE = mgh, where m is the mass of the object, g is the acceleration due to gravity, and h is the height of the object above a reference point. →How can we calculate the change in kinetic energy and gravitational potential energy? To calculate the change in KE, we can use the equation ΔKE = KE_final – KE_initial. To calculate the change in GPE, we can use the equation ΔGPE = GPE_final – GPE_initial. →What is the conservation of energy and how does it apply to KE and GPE? The conservation of energy states that energy cannot be created or destroyed, only transformed from one form to another. In the case of KE and GPE, this means that the total energy of an object remains constant as it transforms from one form of energy to another. →What is the relationship between work done and the change in kinetic energy and gravitational potential energy? Work done is equal to the change in kinetic energy or gravitational potential energy. If work is done on an object, its KE or GPE will increase. Conversely, if work is done by an object, its KE or GPE will decrease. →Can both kinetic energy and gravitational potential energy be negative? Yes, both kinetic energy and gravitational potential energy can be negative. This occurs when an object is moving in the opposite direction to its initial velocity or when it is located below a reference point. →How can we use the concepts of KE and GPE in real-world situations? The concepts of KE and GPE can be used in real-world situations to understand the energy changes that occur during different physical processes. For example, in engineering, the analysis of KE and GPE can be used to design efficient machines and structures. In sports, the analysis of KE and GPE can be used to improve performance. When work is done energy is transferred to the object and it gains gravitational potential energy. If the object falls from that height, the same amount of work would have to be done by the force of gravity to bring it back to the Earth's surface. How do you solve gravitational potential energy problems? What are 3 examples of gravitational potential energy? A raised weight. Water that is behind a dam. A car that is parked at the top of a hill. A yoyo before it is released. River water at the top of a waterfall. A book on a table before it falls. A child at the top of a slide. Ripe fruit before it falls. See also How do you calculate mass defect in physics?Are GPE and work done the same? A person who has climbed to the top of a flight of stairs has transferred chemical energy stored in their muscles to the gravitational potential energy (GPE) they have when standing at the top. Here the work done (measured in joules) is equal to the GPE transferred (also measured in joules). Is gravitational potential energy the same as work done by gravity? The change in gravitational potential energy is equal to the work done by gravity. What is the formula for work done in physics? To express this concept mathematically, the work W is equal to the force f times the distance d, or W = fd. If the force is being exerted at an angle θ to the displacement, the work done is W = fd cos θ. How do you find the gravitational potential energy between two objects? The formula for the gravitational potential energy between two objects is: U=−GMmr , where U is the gravitational potential energy in J , G is the gravitational constant 6.67·10−11m3s2kg , M is the mass of the first object in kg , m is the mass of the second object kg , and r is the distance between the two objects in … The net work done on a particle equals the change in the particle's kinetic energy: W net = K B − K A . What is the relationship between work and energy in physics? Energy should be transferred to an object to move it. Transferring energy can be in the form of force. This amount of energy transferred by the force to move an object is called work or work done. See also How do we calculate the mass of planet?What are 10 examples of potential energy? Pendulum. Spring. Bow & Arrow. Rock At Cliff's Edge. Food We Eat. Water In Dams & Reservoirs. Snow. Bullet. What is a good example of gravitational energy? A good example of gravitational energy is a pendulum that transfers gravitational potential energy to kinetic energy in a repetitive way. In the process, there is no kinetic energy when the ball is at the highest point of the swing, but its gravitational potential energy is at a maximum. An object possesses gravitational potential energy if it is positioned at a height above (or below) the zero height. An object possesses elastic potential energy if it is at a position on an elastic medium other than the equilibrium position. When work done by the gravity is positive then PE of the body? ΔPE is positive when Δh is positive i.e. when h2>h1. So ΔPE represents the work done by the object (or by whatever is moving the object) against the force of gravity mg. If the change in PE is negative (i.e. h2 Potential energy is a state of the system, a way of storing energy as of virtue of its configuration or motion, while work done in most cases is a way of chaning this energy from one body to another. When work is done, there is an exchange in energy. Thus, Work done = Change in energy. See also How do you calculate the potential energy of a molecule?Can work done by gravity be negative? Gravity does negative work here because gravity goes in the opposite direction as the displacement. Is gravitational potential energy negative or positive? This value increases from a large negative value to a small negative value as the object is moved farther from M until it finally reaches zero at an infinite distance. Thus the gravitational potential energy is always negative. As another way of looking at it, for an object to increase in potential energy, external work must be done against the force acting on the object, which means the work done by the force considered will be negative. How do you calculate potential energy examples? PE = m g h. = 2 kg × 9.8 m/s2 × 0.4 m. = 7.84 kg m2/s2 = 7.84 J. What is the total amount of gravitational potential energy? Gravitational potential energy is one type of potential energy and is equal to the product of the object's mass (m), the acceleration caused by gravity (g), and the object's height (h) as distance from the surface of the ground (the body). What is the potential energy of a rock that weighs 150 Newton's that is sitting on top of a hill 200 meters high? Answer: The potential energy of the rock is 30,000 J. W= F × d × costheta. W = F × d. Unit of Work: i.e. W = 20 N m or 20 joule. Example-2: Compute work done for 2-newton force and 3-meter displacement and angle between force and displacement is 45 degree? 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W = 3.51 Nm. See also What are 10 example of conduction? Examples of works : Pushing a car horizontally from rest; shooting a bullet (the powder does the work); walking up stairs; sawing a log. Was this answer helpful? Most people know about the conservation of energy. In a nutshell, it says that energy is conserved; it isn't created and it isn't destroyed, and it simply changes from one form to another. So if you hold a ball completely still, two meters above the ground, and then release it, where does the energy it gains come from? How can something completely still gain so much kinetic energy before it hits the ground? The answer is that the still ball posses a form of stored energy called gravitational potential energy, or GPE for short. This is one of the most important forms of stored energy a high school student will encounter in physics. GPE is a form of mechanical energy caused by the height of the object above the surface of the Earth (or indeed, any other source of a gravitational field). Any object that isn't at the lowest-energy point in such a system has some gravitational potential energy, and if released (i.e., allowed to fall freely), it will accelerate towards the center of the gravitational field until something stops it. Although the process of finding the gravitational potential energy of an object is quite straightforward mathematically, the concept is extraordinarily useful when it comes to calculating other quantities. For example, learning about the concept of GPE makes it really easy to calculate the kinetic energy and the final speed of a falling object. GPE depends on two key factors: the object's position relative to a gravitational field and the mass of the object. The center of mass of the body creating the gravitational field (on Earth, the center of the planet) is the lowest-energy point in the field (although in practice the actual body will stop the falling before this point, as the Earth's surface does), and the farther from this point an object is, the more stored energy it has due to its position. The amount of stored energy also increases if the object is more massive. You can understand the basic definition of gravitational potential energy if you think about a book resting on top of a bookshelf. The book has the potential to fall to the floor because of its elevated position relative to the ground, but one that starts out on the floor can't fall, because it's already on the surface: The book on the shelf has GPE, but the one on the ground doesn't. Intuition will also tell you that a book that's twice as thick will make twice as big a thud when it hits the ground; this is because the mass of the object is directly proportional to the amount of gravitational potential energy an object has. The formula for gravitational potential energy (GPE) is really simple, and it relates mass m, the acceleration due to gravity on the Earth g) and height above the Earth's surface h to the stored energy due to gravity: \(GPE=mgh\) As is common in physics, there are many potential different symbols for gravitational potential energy, including Ug, PEgrav and others. GPE is a measure of energy, so the result of this calculation will be a value in joules (J). The acceleration due to Earth's gravity has a (roughly) constant value anywhere on the surface and points directly to the center of mass of the planet: g = 9.81 m/s2. Given this constant value, the only things you need to calculate GPE are the mass of the object and the height of the object above the surface. So what do you do if you need to calculate how much gravitational potential energy an object has? In essence, you can simply define the height of the object based on a simple reference point (the ground usually works just fine) and multiply this by its mass m and the terrestrial gravitational constant g to find the GPE. For example, imagine a 10-kg mass suspended a height of 5 meters above the ground by a pulley system. How much gravitational potential energy does it have? Using the equation and substituting the known values gives: \(\begin{aligned} GPE&=mgh \ &= 10 \;\text{kg} × 9.81 \;\text{m/s}^2 × 5 \;\text{m}\ &= 490.5 \;\text{J} \end{aligned}\) However, if you've been thinking about the concept while reading this article, you might have considered an interesting question: If the gravitational potential energy of an object on Earth is only truly zero if it's at the center of the mass (i.e., inside the Earth's core), why do you calculate it as if the surface of the Earth is h = 0? The truth is that the choice of the "zero" point for height is arbitrary, and it's usually done to simplify the problem at hand. Whenever you calculate GPE, you're really more concerned about gravitational potential energy changes rather than any sort of absolute measure of the stored energy. In essence, it doesn't matter if you decide to call a tabletop h = 0 rather than the Earth's surface because you're always actually talking about changes in potential energy related to changes in height. Consider, then, somebody lifting a 1.5-kg physics textbook from the surface of a desk, raising it 50 cm (i.e., 0.5 m) above the surface. What is the gravitational potential energy change (denoted ΔGPE) for the book as it is lifted? The trick, of course, is to call the table the reference point, with a height of h = 0, or equivalently, to consider the change in height (Δh) from the initial position. In either case, you get: \(\begin{aligned} ΔGPE &= mgΔh \ &= 1.5 \;\text{kg} × 9.81 \;\text{m/s}^2 × 0.5 \;\text{m}\ &= 7.36 \;\text{J} \end{aligned}\) The precise value for gravitational acceleration g in the GPE equation has a big impact on the gravitational potential energy of an object raised a certain distance above a source of a gravitational field. On the surface of Mars, for instance, the value of g is about three times smaller than on the surface of the Earth, so if you lift the same object the same distance from the surface of Mars, it would have about three times less stored energy than it would on Earth. Similarly, although you can approximate the value of g as 9.81 m/s2 across the Earth's surface at sea level, it's actually smaller if you move a substantial distance away from the surface. For example, if you were on a Mt. Everest, which rises up 8,848 m (8.848 km) above the Earth's surface, being so far away from the center of mass of the planet would reduce the value of g slightly, so you would have g = 9.79 m/s2 at the peak. If you had successfully climbed the mountain and lifted a 2-kg mass 2 m from the peak of the mountain into the air, what would be the change in GPE? Like calculating GPE on another planet with a different value of g, you simply input the value for g that suits the situation and go through the same process as above: \(\begin{aligned} ΔGPE &= mgΔh \ &= 2 \;\text{kg} × 9.79\;\text{m/s}^2 × 2 \;\text{m}\ &= 39.16 \;\text{J} \end{aligned}\) At sea level on Earth, with g = 9.81 m/s2, lifting the same mass would change the GPE by: \(\begin{aligned} ΔGPE &= mgΔh \ &= 2 \;\text{kg} × 9.81\;\text{m/s}^2 × 2 \;\text{m}\ &= 39.24 \;\text{J} \end{aligned}\) This isn't a huge difference, but it clearly shows that altitude does affect the change in GPE when you perform the same lifting motion. And on the surface of Mars, where g = 3.75 m/s2 it would be: \(\begin{aligned} ΔGPE &= mgΔh \ &= 2 \;\text{kg} × 3.75\;\text{m/s}^2 × 2 \;\text{m}\ &= 15 \;\text{J} \end{aligned}\) As you can see, the value of g is very important to the result you get. Performing the same lifting motion in deep space, far away from any influence from the force of gravity, there would be essentially no change in gravitational potential energy. The conservation of energy can be used alongside the concept of GPE to simplify many calculations in physics. In short, under the influence of a "conservative" force, total energy (including kinetic energy, gravitational potential energy and all other forms of energy) is conserved. A conservative force is one where the amount of work done against the force to move an object between two points doesn't depend on the path taken. So gravity is conservative because lifting an object from a reference point to a height h changes the gravitational potential energy by mgh, but it doesn't make a difference whether you move it in an S-shaped path or a straight line – it always just changes by mgh. Now imagine a situation where you're dropping a 500-g (0.5-kg) ball from a height of 15 meters. Ignoring the effect of air resistance and assuming it doesn't rotate during its fall, how much kinetic energy will the ball have at the instant before it contacts with the ground? The key to this problem is the fact that total energy is conserved, so all of the kinetic energy comes from the GPE, and so the kinetic energy Ek at its maximum value must equal the GPE at its maximum value, or GPE = Ek. So you can solve the problem easily: \(\begin{aligned} E_k &= GPE \ &= mgh\ &= 0.5 \;\text{kg} × 9.81\;\text{m/s}^2 × 15 \;\text{m}\ &= 73.58 \;\text{J} \end{aligned}\) The conservation of energy simplifies many other calculations involving gravitational potential energy, too. Think about the ball from the previous example: now that you know the total kinetic energy based on its gravitational potential energy at its highest point, what is the final speed of the ball at the instant before it hits the Earth's surface? You can work this out based on the standard equation for kinetic energy: \(E_k=\frac{1}{2}mv^2\) With the value of Ek known, you can re-arrange the equation and solve for the speed v: \(\begin{aligned} v&=\sqrt{\frac{2E_k}{m}} \ &=\sqrt{\frac{2 × 73.575 \;\text{J}}{0.5\;\text{kg}}} \ &=17.16 \;\text{m/s} \end{aligned}\) However, you can use the conservation of energy to derive an equation that applies to any falling object, by first noting that in situations like this, -ΔGPE = ΔEk, and so: \(mgh = \frac{1}{2}mv^2\) Cancelling m from both sides and re-arranging gives: \(gh = \frac{1}{2}v^2 \ \text{Therefore} \;v= \sqrt{2gh}\) Note that this equation shows that, ignoring air resistance, mass doesn't affect the final speed v, so if you drop any two objects from the same height, they will hit the ground at exactly the same time and fall at the same speed. You can also check the result obtained using the simpler, two-step method and show that this new equation does indeed produce the same result with the correct units. Finally, the previous equation also gives you a way to calculate g on other planets. Imagine that you dropped the 0.5-kg ball from 10 m above the surface of Mars, and recorded a final speed (just before it hit the surface) of 8.66 m/s. What is the value of g on Mars? Starting from an earlier stage in the re-arrangement: \(gh = \frac{1}{2}v^2\) You see that: \(\begin{aligned} g &= \frac{v^2}{2h} \ &= \frac{(8.66 \;\text{m/s})^2}{2 × 10 \;\text{m}} \ &= 3.75 \;\text{m/s}^2 \end{aligned}\) The conservation of energy, in combination with the equations for gravitational potential energy and kinetic energy, has many uses, and when you get used to exploiting the relationships, you'll be able to solve a huge range of classical physics problems with ease. Johnson, Lee. "Gravitational Potential Energy: Definition, Formula, Units (W/ Examples)" sciencing.com, . 22 December 2020. APA Johnson, Lee. (2020, December 22). Gravitational Potential Energy: Definition, Formula, Units (W/ Examples). sciencing.com. Retrieved from Chicago Johnson, Lee. Gravitational Potential Energy: Definition, Formula, Units (W/ Examples) last modified August 30, 2022. Gravitational potential energy is the energy possessed by an object due to its position in a gravitational field. When the object moves from one position to another, its gravitational potential energy change equals the work done in moving the object. Gravitational potential energy is also associated with the Earth, which we know as gravity. An object at a specific height above the Earth's surface possesses gravitational potential energy. When the object is released, its potential energy is converted into kinetic energy. The sum of the two always remains constant because of the conservation of energy law. Gravitational potential energy helps us to understand the motion of planets. When scientists send spacecraft to other planets, they can precisely calculate how much energy is needed to fuel them. Gravitational Potential Energy English mathematician and physicist Isaac Newton published his comprehensive theory of gravitation in 1687. A car on top of a hillA roller coaster at its highest pointA child on top of a slideThe water behind a dam wallAn apple in a treeA book on a tableA pendulum at its extreme endsFlower pots hanging off of the deck The general equation for gravitational potential energy comes from the universal law of gravitation. According to this law, every object possesses gravitational force due to its mass. Consider two massive objects in space. Let us call them source and test objects. The energy stored by the test object when brought from infinity to a point inside a gravitational field is \[U_g = – \frac{GM_1 M_2}{d} \] Where Ug: Gravitational potential energy M1: Mass of the source object M2: Mass of the test object d: Distance of separation between the two objects G: Universal gravitational constant (= 6.67 x 10-11 m3 kg-1 s-2) Symbol: Ug SI Unit: Joules Dimension: [ML2T-2] Gravitational Potential Energy Formula The gravitational force does positive work in bringing the test object from infinity to a point inside the gravitational field. Because of its inverse square nature, the gravitational force is zero at infinity. Therefore, infinity is taken as the reference point. Moreover, the source object binds the test object to an orbit. This "bound state" results in negative potential energy, as seen in the equation. The Earth has a gravitational force which we all know as the force due to gravity. The acceleration due to gravity can be considered to be approximately constant. The expression for the gravitational potential energy of an object relative to the Earth's surface is \[U_E = mgh \] Where UE: Gravitational potential energy due to Earth m: Mass of the object h: Height of the object above the Earth's surface g: Acceleration due to gravity (=9.81 m/s2) From the above equation, it is clear that the gravitational potential energy due to Earth depends upon two factors – the object's mass and height. The heavier the object, the greater the energy. Similarly, the higher the object, the higher its potential energy. When the object is raised from the ground to a height h, the change is gravitation potential energy is \[\Delta U_E = U_{final} – U_{initial} = mgh – 0 \] This change is equal to the work done in lifting the object. Gravitational Potential Energy Earth We know that the work done is force times displacement. The infinitesimal work dW done to move the test object by a distance dx is given by \[dW = F_g dx \] Where Fg is the gravitational force. At a distance x from the source object, it is given by \[F_g = \frac{GM_1M_2}{x^2} \] Replacing Fg in the dW equation \[dW = \frac{GM_1M_2}{x^2} dx \] Integrating the above from infinity to d \[W = \int^d_\infty dW = \int^d_\infty \frac{GM_1M_2}{x^2} dx \\ \Rightarrow W = -\frac{GM_1M_2}{d} \] Since the work done is the change in gravitational potential energy, we have \[W = \Delta U_g = U_{final} – U_{initial} \\ \Rightarrow -\frac{GM_1M_2}{d} = U_g – 0 \\ \Rightarrow U_g = -\frac{GM_1M_2}{d} \] The amount of energy required to move a unit mass from infinity to a point inside the influence of a gravitational field due to a source mass M. It is given by the following expression. \[V_g = -\frac{GM}{d} \] Article was last reviewed on Thursday, September 29, 2022 By the end of this section, you will be able to do the following: Describe and apply the work–energy theorem Describe and calculate work and power The learning objectives in this section will help your students master the following standards: (6) Science concepts. The student knows that changes occur within a physical system and applies the laws of conservation of energy and momentum. The student is expected to: (A) describe and apply the work–energy theorem; (C) describe and calculate work and power. In addition, the High School Physics Laboratory Manual addresses the following standards: (6) Science concepts. The student knows that changes occur within a physical system and applies the laws of conservation of energy and momentum. The student is expected to: (C) calculate the mechanical energy of, power generated within, impulse applied to, and momentum of a physical system. Use the lab titled Work and Energy as a supplement to address content in this section. energy gravitational potential energy joule kinetic energy mechanical energy potential energy power watt work work–energy theorem In this section, students learn how work determines changes in kinetic energy and that power is the rate at which work is done. [BL][OL] Review understanding of mass, velocity, and acceleration due to gravity. Define the general definitions of the words potential and kinetic. [AL][AL] Remind students of the equation W=P E e =fmg W=P E e =fmg . Point out that acceleration due to gravity is a constant, therefore PEe that results from work done by gravity will also be constant. Compare this to acceleration due to other forces, such as applying muscles to lift a rock, which may not be constant. In physics, the term work has a very specific definition. Work is application of force, ff, to move an object over a distance, d, in the direction that the force is applied. Work, W, is described by the equation W=fd. W=fd. Some things that we typically consider to be work are not work in the scientific sense of the term. Let's consider a few examples. Think about why each of the following statements is true. Homework is not work. Lifting a rock upwards off the ground is work. Carrying a rock in a straight path across the lawn at a constant speed is not work. The first two examples are fairly simple. Homework is not work because objects are not being moved over a distance. Lifting a rock up off the ground is work because the rock is moving in the direction that force is applied. The last example is less obvious. Recall from the laws of motion that force is not required to move an object at constant velocity. Therefore, while some force may be applied to keep the rock up off the ground, no net force is applied to keep the rock moving forward at constant velocity. [BL][OL] Explain that, when this theorem is applied to an object that is initially at rest and then accelerates, the 1 2 m v 1 2 1 2 m v 1 2 term equals zero. [OL][AL] Work is measured in joules and W=fd W=fd . Force is measured in newtons and distance in meters, so joules are equivalent to newton-meters (N·m) (N·m) Work and energy are closely related. When you do work to move an object, you change the object's energy. You (or an object) also expend energy to do work. In fact, energy can be defined as the ability to do work. Energy can take a variety of different forms, and one form of energy can transform to another. In this chapter we will be concerned with mechanical energy, which comes in two forms: kinetic energy and potential energy. Kinetic energy is also called energy of motion. A moving object has kinetic energy. Potential energy, sometimes called stored energy, comes in several forms. Gravitational potential energy is the stored energy an object has as a result of its position above Earth's surface (or another object in space). A roller coaster car at the top of a hill has gravitational potential energy. Let's examine how doing work on an object changes the object's energy. If we apply force to lift a rock off the ground, we increase the rock's potential energy, PE. If we drop the rock, the force of gravity increases the rock's kinetic energy as the rock moves downward until it hits the ground. The force we exert to lift the rock is equal to its weight, w, which is equal to its mass, m, multiplied by acceleration due to gravity, g. f=w=mg f=w=mg The work we do on the rock equals the force we exert multiplied by the distance, d, that we lift the rock. The work we do on the rock also equals the rock's gain in gravitational potential energy, PEe. W=P E e =mgd W=P E e =mgd Kinetic energy depends on the mass of an object and its velocity, v. KE= 1 2 m v 2 KE= 1 2 m v 2 When we drop the rock the force of gravity causes the rock to fall, giving the rock kinetic energy. When work done on an object increases only its kinetic energy, then the net work equals the change in the value of the quantity 1 2 m v 2 1 2 m v 2 . This is a statement of the work–energy theorem, which is expressed mathematically as W=ΔKE = 1 2 m v 2 2 − 1 2 m v 1 2 . W=ΔKE = 1 2 m v 2 2 − 1 2 m v 1 2 . The subscripts 2 and 1 indicate the final and initial velocity, respectively. This theorem was proposed and successfully tested by James Joule, shown in Figure 9.2. Does the name Joule sound familiar? The joule (J) is the metric unit of measurement for both work and energy. The measurement of work and energy with the same unit reinforces the idea that work and energy are related and can be converted into one another. 1.0 J = 1.0 N•m, the units of force multiplied by distance. 1.0 N = 1.0 kg•m/s2, so 1.0 J = 1.0 kg•m2/s2. Analyzing the units of the term (1/2)mv2 will produce the same units for joules. Figure 9.2 The joule is named after physicist James Joule (1818–1889). (C. H. Jeens, Wikimedia Commons) This video explains the work energy theorem and discusses how work done on an object increases the object's KE. True or false—The energy increase of an object acted on only by a gravitational force is equal to the product of the object's weight and the distance the object falls. Repeat the information on kinetic and potential energy discussed earlier in the section. Have the students distinguish between and understand the two ways of increasing the energy of an object (1) applying a horizontal force to increase KE and (2) applying a vertical force to increase PE. In applications that involve work, we are often interested in how fast the work is done. For example, in roller coaster design, the amount of time it takes to lift a roller coaster car to the top of the first hill is an important consideration. Taking a half hour on the ascent will surely irritate riders and decrease ticket sales. Let's take a look at how to calculate the time it takes to do work. Recall that a rate can be used to describe a quantity, such as work, over a period of time. Power is the rate at which work is done. In this case, rate means per unit of time. Power is calculated by dividing the work done by the time it took to do the work. P= W t P= W t Let's consider an example that can help illustrate the differences among work, force, and power. Suppose the woman in Figure 9.3 lifting the TV with a pulley gets the TV to the fourth floor in two minutes, and the man carrying the TV up the stairs takes five minutes to arrive at the same place. They have done the same amount of work (fd) (fd) on the TV, because they have moved the same mass over the same vertical distance, which requires the same amount of upward force. However, the woman using the pulley has generated more power. This is because she did the work in a shorter amount of time, so the denominator of the power formula, t, is smaller. (For simplicity's sake, we will leave aside for now the fact that the man climbing the stairs has also done work on himself.) Figure 9.3 No matter how you move a TV to the fourth floor, the amount of work performed and the potential energy gain are the same. Power can be expressed in units of watts (W). This unit can be used to measure power related to any form of energy or work. You have most likely heard the term used in relation to electrical devices, especially light bulbs. Multiplying power by time gives the amount of energy. Electricity is sold in kilowatt-hours because that equals the amount of electrical energy consumed. The watt unit was named after James Watt (1736–1819) (see Figure 9.4). He was a Scottish engineer and inventor who discovered how to coax more power out of steam engines. Figure 9.4 Is James Watt thinking about watts? (Carl Frederik von Breda, Wikimedia Commons) [BL][OL] Review the concept that work changes the energy of an object or system. Review the units of work, energy, force, and distance. Use the equations for mechanical energy and work to show what is work and what is not. Make it clear why holding something off the ground or carrying something over a level surface is not work in the scientific sense. [OL] Ask the students to use the mechanical energy equations to explain why each of these is or is not work. Ask them to provide more examples until they understand the difference between the scientific term work and a task that is simply difficult but not literally work (in the scientific sense). [BL][OL] Stress that power is a rate and that rate means "per unit of time." In the metric system this unit is usually seconds. End the section by clearing up any misconceptions about the distinctions between force, work, and power.[AL] Explain relationships between the units for force, work, and power. If W=fd W=fd and work can be expressed in J, then P= W t = fd t P= W t = fd t so power can be expressed in units of N·m s N·m s Also explain that we buy electricity in kilowatt-hours because, when power is multiplied by time, the time units cancel, which leaves work or energy. James Watt did not invent the steam engine, but by the time he was finished tinkering with it, it was more useful.

Ottoman territory. March 12 – Moscow becomes the capital of Soviet Russia. March 15 – Finnish Civil War: The battle of Tampere begins.[6] March 19 – The United States Congress establishes time zones, and approves daylight saving time (DST goes into effect on March 31). March 21–July 18 – WWI: The Spring Offensive by the German Army along the Western Front fails to make a breakthrough, despite large losses on each side, including nearly 20,000 British Army dead on the first day, Operation Michael, on the Somme. March 21 – WWI: The First Transjordan attack on Amman by units of the Egyptian Expeditionary Force begins, with the passage of the Jordan River. March 23 WWI: The giant German cannon, the 'Paris Gun' (Kaiser Wilhelm Geschütz), begins to shell Paris from 114 km (71 mi) away. In London at the Wood Green Empire, Chung Ling Soo (William E. Robinson, U.S.-born magician) dies during his trick, where he is supposed to "catch" two separate bullets (but one of them perforates his lung). He dies the following morning in a hospital. March 25 The Belarusian People's Republic declares independence. Karl Muck, music director of the Boston Symphony Orchestra, is arrested under the Alien Enemies Act, and imprisoned for the duration of WWI. March 26 – Marie Stopes publishes her influential book Married Love in the U.K. March 27 – WWI: The First Battle of Amman is launched by units of the Egyptian Expeditionary Force, during the First Transjordan attack on Amman; it ends with their withdrawal on 31 March, back to the Jordan Valley. March 30 – March Days: Bolshevik and Armenian Revolutionary Federation forces suppress a Muslim revolt in Baku, Azerbaijan, resulting in up to 30,000 deaths. Main article: April 1918 Styles of Lucy, Lady Duff-Gordon, as presented in a vaudeville circuit pantomime and sketched by Marguerite Martyn of the St. Louis Post-Dispatch in April 1918 April 1 – The Royal Flying Corps and the Royal Naval Air Service in Britain are merged to form the Royal Air Force, the first autonomous Air Force in the world. April 5 – Sālote succeeds as Queen of Tonga; she will remain on the throne until her death in 1965. April 6 – Finnish Civil War: The battle of Tampere ends.[6] April 8 – Operations against the Marri and Khetran tribes in Balochistan end with surrender to the British authorities. April 9 – Union of Bessarabia with Romania: Bessarabia votes to become part of the Kingdom of Romania. April 21 – WWI: Manfred von Richthofen, "The Red Baron", the war's most successful fighter pilot, dies in combat at Morlancourt Ridge near the Somme River. April 22 – Armenia, Azerbaijan, and Georgia declare their independence from Russia as the Transcaucasian Democratic Federative Republic. April 23 – WWI: Conscription Crisis of 1918 in Ireland: A general strike is held here against conscription. Zeebrugge Raid: The British Royal Navy attempts to seal off the German U-boat base here.[7] First Ostend Raid: The British Royal Navy unsuccessfully attempts to seal off the German U-boat base here. April 28 – WWI: Gavrilo Princip, assassin of Archduke Franz Ferdinand of Austria, dies in Terezin, Austria-Hungary, after three years in prison. April 30 – WWI: The Second Transjordan attack on Shunet Nimrin and Es Salt, launched by units of the Egyptian Expeditionary Force, ends on 4 May, with their withdrawal back to the Jordan Valley. Main article: May 1918 May 1 – WWI: German troops enter Don Host Oblast; they capture Rostov-on-Don on May 8. May 2 – General Motors acquires the Chevrolet Motor Company of Delaware. May 7 – WWI: The British capture Kirkuk. May 9 – WWI – Second Ostend Raid: The British Royal Navy unsuccessfully attempts, for a second time, to seal off the German U-boat base here. May 11 – The Mountainous Republic of the Northern Caucasus is officially established. May 12 - The HMT Olympic rams into the SM U-103, sinking it. resulting in the deaths of 9 people May 14 – The Three Minute Pause, initiated by the daily firing of the Noon Gun on Signal Hill, is instituted by Cape Town Mayor Sir Harry Hands. It will inspire the introduction of the two-minute silence in November 1919.[8] May 15 The Finnish Civil War ends. The United States Post Office Department begins the world's third regular airmail service, between New York City, Philadelphia and Washington, D.C.[9] May 16 – The Sedition Act of 1918 is approved by the U.S. Congress. May 20 – The small town of Codell, Kansas is hit for the third year in a row, on the same date, by a tornado. May 21 – The United States Army Aviation Section is separated from the Signal Corps, and divided into the Division of Military Aeronautics and the Bureau of Aircraft Production. May 24 – Women in Canada, excluding residents of Quebec, are granted the right to vote in federal elections.[10] May 26 – The Transcaucasian Democratic Federative Republic is abolished; Georgia declares its independence as the Democratic Republic of Georgia. May 27 – WWI: The Third Battle of the Aisne commences. May 28 – Armenia and Azerbaijan declare their independence as the First Republic of Armenia and the Azerbaijan Democratic Republic respectively. May 29 – WWI: The week-long Battle of Sardarabad concludes with defending Armenian forces victorious over the Ottomans. May 29–30 – WWI: Battle of Skra di Legen – The Greek National Defence Army Corps defeats the Bulgarians. June 10: Austro-Hungarian battleship Szent István sunk by Italian torpedo boats Szent István Main article: June 1918 June–August – The "Spanish flu" becomes pandemic.[11] Over 30 million people die in the following 6 months. June 1 – WWI: The Battle of Belleau Wood begins. June 4 – RMS Kenilworth Castle, one of the Union-Castle Line steamships, collides with her escort destroyer HMS Rival while trying to avoid her other escort, the cruiser HMS Kent. June 8 – V603 Aquilae, the brightest nova observed since Kepler's of 1604, is discovered. June 10 – WWI: The Austro-Hungarian dreadnought battleship SMS Szent István is sunk by two Italian MAS motor torpedo boats off the Dalmatian coast. June 12 Grand Duke Michael of Russia is murdered, thereby becoming the first of the Romanovs to be killed by the Bolsheviks. WWI: The first airplane bombing raid by an American unit in France is carried out. June 16 – The Declaration to the Seven, a British government response to a memorandum issued anonymously by seven Syrian notables, is published. June 22 – Suspects in the Chicago Restaurant Poisonings are arrested, and more than 100 waiters are taken into custody for poisoning restaurant customers with a lethal powder called Mickey Finn. June 29 – Bronx International Exposition of Science, Arts and Industries opens in New York; Brazil is the only international exhibitor and the exposition closes at the end of the season.[12] Main article: July 1918 July 3 – Allied intervention in the Russian Civil War: The Siberian Intervention is launched by the Allies, to extract the Czechoslovak Legion from the Russian Civil War. July 4 – Mehmed VI succeeds as Sultan of the Ottoman Empire on the death of his half-brother Mehmed V (Reşâd, who has reigned since 1909), himself reigning until the Sultanate is abolished in 1922. July 12 – The Imperial Japanese Navy battleship Kawachi blows up off Tokuyama, Yamaguchi, western Honshu, Japan, killing at least 621. July 13 – The National Czechoslovak Committee is established. July 14 – The film The Glorious Adventure is released in the United States, featuring Mammy Lou, who becomes one of the oldest people ever to star in a film, at a claimed age of 114. July 14 – WWI: Second Battle of the Marne: The battle begins near the River Marne, with a German attack. July 14 – Quentin Roosevelt, Theodore Roosevelt's youngest son, is killed in action during the Second Battle of the Marne. July 17: Execution of the Romanov family July 17 WWI: RMS Carpathia (famed for rescuing survivors of the RMS Titanic) is torpedoed and sunk off the east coast of Ireland, by Imperial German Navy submarine U-55; 218 of the 223 on board are rescued.[13] Execution of the Romanov family: By order of the Bolshevik Party, and carried out by the Cheka, former emperor Nicholas II, his wife Alexandra Feodorovna, their children, Olga, Tatiana, Maria, Anastasia, Alexei and retainers are shot at the Ipatiev House, in Ekaterinburg, Russia. July 21 – WWI: Attack on Orleans – Imperial German submarine SM U-156 surfaces and fires on a small convoy of barges and defending flying boats off the Cape Cod town of Orleans, Massachusetts.[14] Main article: August 1918 August 2 – North Russia Intervention: Anti-Bolshevik forces stage a coup at Arkhangelsk, and an occupation by Allied forces follows.[15] August 3 – WWI: Australian hospital ship HMAT Warilda is torpedoed and sunk in the English Channel on passage from Le Havre to Southampton by German submarine SM UC-49 with the loss of 123 of the 801 people on board.[16] August 8 – WWI: Battle of Amiens – British, Canadian and Australian troops begin a string of almost continuous victories, the 'Hundred Days Offensive', with an 8-mile push through the German front lines, taking 12,000 prisoners. German General Erich Ludendorff later calls this the "black day of the German army".[17] August 10 – Russian Revolution: The British commander in Archangel is told to help the White Russians. August 16 – The Battle of Lake Baikal is fought by the Czechoslovak legion, against the Red Army. August 21 – WWI: The Second Battle of the Somme begins. August 23 – The Bessarabian Peasants' Party is created. August 27 – Battle of Ambos Nogales: U.S. Army forces skirmish against Mexican Carrancistas and their German advisors at Nogales, Arizona, in the only battle of WWI fought on United States soil. August 30 In response to the October Revolution in Russia, Vladimir Lenin is shot and wounded by Fanny Kaplan in Moscow, but survives.[18] Moisei Uritsky, the Petrograd head of the Cheka, is assassinated. August 30: Attempted assassination of Lenin, depicted by Vladimir Pchelin Main article: September 1918 September – WWI: British armies and their Arab allies roll into Syria. September 3 – The Bolshevik government of Russia publishes the first official announcement of the Red Terror, a period of repression against political opponents, as an "Appeal to the Working Class" in the newspaper Izvestia.[19] September 4 – WWI: Battle of Mont Saint-Quentin concludes with the Australian Corps breaking the German line. September 5 – Russian Civil War: The Kazan Operation begins. The event continues for 5 days, and solidifies the Red Army's power in Russia over the White Army. September 12 – WWI: Battle of Havrincourt – The British take a German salient. September 12–15 – WWI: Battle of Saint-Mihiel – Americans take a German salient. September 14 – WWI: The Balkan front offensive by the Serbian Army begins. September 15–18 – WWI: Battle of Dobro Pole in the Vardar Offensive of the Balkans Campaign: The Allied Army of the Orient defeats Bulgarian defenders. September 18 – WWI: Battle of Épehy – British approach the Hindenburg Line along the St Quentin Canal. September 19 – WWI: The British Army's Egyptian Expeditionary Force launches the Battle of Megiddo, incorporating the Battle of Sharon, and the Battle of Nablus, an attack in the Judaean Mountains. This day are fought the Battle of Tulkarm, and the Battle of Arara, which break the Ottoman front line stretching from the Mediterranean coast to the Judaean Mountains, while the Battle of Tabsor extends into September 20. The Third Transjordan attack in the Jordan Valley begins. September 20 – WWI: The British Army's Desert Mounted Corps launches the Battle of Nazareth by 5th Cavalry Division (British Indian Army); Capture of Afulah and Beisan by the 4th Cavalry Division (British Indian Army); Capture of Jenin by the Australian Mounted Division, almost encircling the Yildirim Army Group still in the Judaean Mountains. September 25 – WWI: The Battle of Megiddo ends with the Battle of Haifa, Battle of Samakh, and Capture of Tiberias. The Third Transjordan attack ends with ANZAC Mounted Division victory at the Second Battle of Amman, with the subsequent capture at Ziza of the Ottoman II Corps, and more than 10,000 Ottoman and German prisoners. September 26 – WWI: The Meuse-Argonne Offensive begins, the largest and bloodiest operation of the war for the American Expeditionary Forces. The Capture of Damascus begins, with the Charge at Irbid by the 4th Cavalry Division. September 27 – WWI The Battle of the Canal du Nord, launched by British and Empire forces, continues the advance towards the Hindenburg Line. The Battle of Jisr Benat Yakub, launched by the Australian Mounted Division, continues the advance towards Damascus. September 29 – WWI: Battle of St Quentin Canal begins; Allied forces advance towards the Hindenburg Line. Bulgaria requests an armistice, with the Armistice of Salonica being signed and coming into force the next day. September 30 – WWI: The Charge at Kaukab is begun by units of the Australian Mounted Division. The Charge at Kiswe is begun by 4th Cavalry Division, continuing the Desert Mounted Corps' advance to Damascus. Main article: October 1918 October 1 – WWI: The Desert Mounted Corps captures Damascus. October 2 – WWI: The Charge at Khan Ayash is begun north of Damascus, by the 3rd Light Horse Brigade. October 3 Kaiser Wilhelm II of Germany appoints Max von Baden Chancellor of Germany. King Ferdinand I of Bulgaria abdicates in the wake of the Bulgarian military collapse in WWI. He is succeeded by his son, Boris III. WWI: The Pursuit to Haritan by the Desert Mounted Corps begins. October 4 Wilhelm II of Germany forms a new, liberal government to sue for peace. The T. A. Gillespie Company Shell Loading Plant explosion in New Jersey kills 100+, and destroys enough ammunition to supply the Western Front for 6 months. October 7 – The Regency Council (Poland) declares Polish independence from the German Empire, and demands that Germany cede the Polish provinces of Poznań, Upper Silesia and Polish Pomerania. October 8–10 – WWI: Second Battle of Cambrai: British and Canadian troops take Cambrai from the Germans and the First and Third British Armies break through the Hindenburg Line. October 8 – WWI: In the Forest of Argonne in France, U.S. Corporal Alvin C. York almost single-handedly kills 25 German soldiers and captures 132. October 9 – Landgrave Prince Frederick Charles of Hesse is elected King of Finland. October 11 – The magnitude (Mw) 7.1 San Fermín earthquake shakes Puerto Rico with a maximum Mercalli intensity of IX (Violent), killing 76–116 people. A destructive tsunami contributes to the damage and loss of life. October 12 – Cloquet Fire: The city of Cloquet, Minnesota, and nearby areas are destroyed in a fire, killing 453. October 16 – Emperor Karl IV of Austria publishes the Völkermanifest manifesto, declaring the Cisleithanian part of the empire will be federalized on the basis of national councils October 18 – The Washington Declaration proclaims the independent Czechoslovak Republic. October 21 – German representatives of the Reichsrat in Austria-Hungary form the Provisional National Assembly for German-Austria October 24 – WWI: The Battle of Vittorio Veneto opens. October 25 WWI: Aleppo is captured, by Prince Feisal's Sheifial Forces. The steamer Princess Sophia sinks on Vanderbilt Reef near Juneau, Alaska; 353 people die, in the greatest maritime disaster in the Pacific Northwest. October 26 – WWI – Charge at Haritan: Units of the Desert Mounted Corps battle with Ottoman forces for the last time in WWI. October 28 Czechoslovakia declares its independence from Austria-Hungary. A new Polish government is declared in Western Galicia (Eastern Europe). October 29 The Wilhelmshaven mutiny of the German High Seas Fleet breaks out. The State of Slovenes, Croats and Serbs declares its independence from Austria-Hungary. October 30 The Martin Declaration is published, including Slovakia in the formation of the Czecho-Slovak state. The Armistice of Mudros ends conflict between the Ottoman Empire and the Allies of World War I, and grants independence to the Mutawakkilite Kingdom of Yemen. October 31 – Revolution overthrows the pro-Habsburg government in Hungary, effectively dissolving the Austro-Hungarian Empire. Main article: November 1918 November 1 The Polish–Ukrainian War is inaugurated, by the proclamation of the West Ukrainian People's Republic in Galicia, with a capital at Lwów. Serbian forces recapture Belgrade. Malbone Street Wreck: The worst rapid transit accident in world history occurs under the intersection of Malbone Street and Flatbush Avenue, in Brooklyn, New York City, with at least 93 dead. November 3 WWI: The Armistice of Villa Giusti is signed between Austria-Hungary and the Allies near Padua. Poland declares its independence from Russia. German Revolution: Kiel mutiny by sailors in the German fleet at Kiel while throughout northern Germany soldiers and workers begin to establish revolutionary councils on the Russian soviet model. November 4 – WWI: The Armistice of Villa Giusti comes into effect, ending warfare between Italy and Austria-Hungary on the Italian Front. November 6 – A new Polish government is proclaimed in Lublin. November 7 – King Ludwig of Bavaria flees his country. November 8 – The German army withdraws its support of the Kaiser. The German Armistice delegation arrives at the Forest of Compiègne in France. November 9: Proclamation of German Republic by Philipp Scheidemann in Berlin on the Reichstag balcony November 9 Kaiser Wilhelm II of Germany abdicates and chooses to live in exile in the Netherlands. Proclamation of the republic in Germany by Philipp Scheidemann in Berlin, on the Reichstag balcony. One of several significant events on 9 November in German history. Provisional National Council Minister-President Kurt Eisner declares Bavaria to be a republic. British battleship HMS Britannia is sunk by a German submarine off Trafalgar, with the loss of around fifty lives (the last major naval engagement of WWI). Signatories to the Armistice of 11 November 1918 with Germany, ending WWI, pose outside Marshal Foch's railway carriageNovember 11: Front page of The New York Times on Armistice Day November 10 Luxembourg communist forces rebel in Luxembourg city, beginning the Luxembourg rebellions.[20] November 11 End of WWI: Armistice of 11 November 1918 – Germany signs an armistice agreement with the Allies, between 5:12 AM and 5:20 AM, in the "Compiègne Wagon", Marshal Foch's railroad car, in the Forest of Compiègne in France. It becomes official on the 11th hour of the 11th day of the 11th month.[21] At 10:59 U.S. soldier Henry Gunther becomes (probably) the last killed in action. Poland regains independence, after 123 years of partitions. Józef Piłsudski is appointed Commander-in-Chief. Emperor Charles I of Austria gives up his absolute power, but does not abdicate. Loppem Agreements: Start of a series of political meetings between King Albert I and Belgian liberals and socialists. Red Week: Pieter Jelles Troelstra gives a speech calling for socialist revolution in the Netherlands. November 12 – Austria becomes a republic. November 13 The Allied Occupation of Constantinople begins. Frederick II, Grand Duke of Baden, relinquishes all governing duties. November 14 Czechoslovakia becomes a republic. The Second Polish Republic is proclaimed with Józef Piłsudski as head of state. The provisional government of Baden proclaims the "Free People's Republic of Baden" (Freie Volksrepublik Baden). Ernest Louis, Grand Duke of Hesse, is forced from his throne, leading to the establishment of the People's State of Hesse. Frederick Francis IV, Grand Duke of Mecklenburg-Schwerin abdicates his throne, leading to the establishment of the Free State of Mecklenburg-Schwerin. Charles Edward, Duke of Saxe-Coburg and Gotha, announces he is ceasing to rule Saxe-Coburg and Gotha, leading to the establishment of the Free State of Coburg. German East African troops are informed of the November 11 armistice. November 16 – The Hungarian Democratic Republic is declared, marking Hungary's independence from Austria. November 18 – Latvia declares its independence from Russia. November 20 – U-boats start to rendezvous off Harwich, to begin the surrender of the High Seas Fleet to the British Royal Navy; in the following week the German warships are escorted to internment in Scapa Flow.[22] November 21 – Lwów pogrom: Polish troops, volunteers and freed criminals massacre at least 320 Ukrainian Christians and Jews in Lwów, Galicia. November 22 The Belgian royal family returns to Brussels after the war, King Albert I having commanded the Allied army group in the September–October Courtrai offensive, which liberated his country. Frederick II, Grand Duke of Baden, abdicates; the Grand Duchy of Baden gives way to the Republic of Baden. November 23 – British military government of Palestine begins.[23] November 25 – General Paul von Lettow-Vorbeck, German commander in German East Africa, signs a ceasefire at Abercorn in Northern Rhodesia. November 26 – The Podgorica Assembly ('Great National Assembly of the Serb People in Montenegro') votes for a "union of the people" between the kingdoms of Montenegro and Serbia and for deposition of the exiled King Nicholas I of Montenegro.[24] November 28 – Estonian War of Independence: The Red Army invades Estonia, starting the war. The Commune of the Working People of Estonia is established as a Soviet puppet state in Narva on the next day. November 29 – Serbia annexes Montenegro, suspending the latter's existence as a sovereign state for nearly the entirety of the following 88 years.[25] November 30 – Ernest Ansermet conducts the first concert by the Orchestre de la Suisse Romande. Main article: December 1918 December 1 By the Danish–Icelandic Act of Union, Iceland regains independence, but remains in personal union with the King of Denmark, who also becomes the King of Iceland. New voting laws in Sweden makes votes no longer dependent on taxable assets, each adult having one vote. The Union of Alba Iulia is proclaimed: Following the March 27 incorporation of Bessarabia and Bucovina, Transylvania unites with the Kingdom of Romania. The Kingdom of Serbs, Croats and Slovenes (which later becomes the Kingdom of Yugoslavia) is proclaimed, in particular ending Serbia's existence as a sovereign state for the next 87 years (it would not regain its sovereignty until 2006).[25] Flag of the Kingdom of Serbs, Croats and Slovenes December 4 – President Woodrow Wilson departs by ship to the Paris Peace Conference, becoming the first United States President to travel to Europe while holding office. December 5 – Estonian War of Independence: The British light cruiser HMS Cassandra strikes a mine and sinks near Saaremaa in the Baltic Sea, killing 11 sailors.[26] December 6 – A magnitude (Mw) 7.2 earthquake shakes British Columbia. December 14 Prince Frederick Charles of Hesse renounces the Finnish throne.[27] Portuguese President Sidónio Pais is assassinated. Giacomo Puccini's comic opera Gianni Schicchi premiered at the Metropolitan Opera in New York City.[28] December 16 – Vincas Mickevičius-Kapsukas declares the formation of the Lithuanian Soviet Socialist Republic, a puppet state created by the Russian SFSR to justify the Lithuanian–Soviet War. December 17 – Darwin Rebellion in Australia: Disaffected workers march on Government House, Darwin, demanding the resignation of the Administrator of the Northern Territory, John A. Gilruth. December 20 – Tomáš Garrigue Masaryk returns to the Czechoslovak Republic. December 21 – Estonian War of Independence: The Red Army captures Tartu, Estonia. December 25 – Der Stahlhelm, Bund der Frontsoldaten, is formed in Germany as a nationalist veterans' organization. December 27 – Greater Poland Uprising (1918–19): Poles in Greater Poland (the former Grand Duchy of Posen) rise up against the Germans, ignited by a patriotic speech made in Poznań by pianist and politician Ignacy Jan Paderewski. December 28 – Sinn Féin enjoys a landslide victory in Irish seats in the Irish general election (part of the 1918 United Kingdom general election), following the counting of votes, winning 73 of the 105 seats in Ireland. In accordance with their manifesto, Sinn Féin members will not take their seats in the Palace of Westminster but will form the First Dáil in Dublin. Countess Constance Markievicz, while detained in Holloway Prison (London), becomes the first woman elected to (but does not take her seat in) the British House of Commons.[29] December 31 – A British-brokered ceasefire ends the two weeks of fighting in the Georgian–Armenian War. Nakajima Aircraft Company, a predecessor of the Subaru car manufacturing company in Japan, is founded in Ota, Gunma Prefecture.[citation needed] João Figueiredo Gamal Abdel Nasser Gertrude B. Elion Nicolae Ceaușescu January 1 – Patrick Anthony Porteous, Scottish recipient of the Victoria Cross (d. 2000) January 2 – Gudrun Zapf-von Hesse, German typographer, calligrapher and book-binder (d. 2019) January 10 – Arthur Chung, 1st President of Guyana (d. 2008) January 11 – Kassim Al-Rimawi, Prime Minister of Jordan (d. 1982) January 15 João Figueiredo, 30th President of Brazil (d. 1999) Gamal Abdel Nasser, 2nd President of Egypt (d. 1970) January 16 – Stirling Silliphant, American writer, producer (d. 1996)[30] January 17 Kamal Amrohi, Indian director, screenwriter (d. 1993) George M. Leader, American politician (d. 2013) January 20 – Juan García Esquivel, Mexican bandleader (d. 2002) January 21 Chicháy, Filipino actress (d. 1993) Richard Winters, U.S. Army officer (d. 2011)[31] January 22 – Elmer Lach, Canadian ice hockey player (d. 2015) January 23 – Gertrude B. Elion, American scientist, recipient of the Nobel Prize in Physiology or Medicine (d. 1999)[32] January 24 – Oral Roberts, American neo-Pentecostal televangelist (d. 2009) January 26 Nicolae Ceaușescu, Romanian communist politician and leader (d. 1989) Philip José Farmer, American writer (d. 2009) January 27 Skitch Henderson, English-born musician, bandleader (d. 2005) Elmore James, American musician (d. 1963) January 29 Luis Aguilar, Mexican actor, and singer (d. 1997) John Forsythe, American actor (d. 2010) January 31 – Millie Dunn Veasey, African-American civil rights activist (d. 2018) Joey Bishop Julian Schwinger February 1 Carlos Fayt, Argentine lawyer, politician and academic (d. 2016) Dame Muriel Spark, Scottish author (d. 2006) February 2 – Hella Haasse, Dutch writer (d. 2011) February 3 Joey Bishop, American entertainer, member of the "Rat Pack" (d. 2007) Helen Stephens, American runner (d. 1994) February 4 – Ida Lupino, Anglo-American actress, screenwriter, director and producer (d. 1995) February 6 – Lothar-Günther Buchheim, German author (d. 2007) February 7 – Marguerite Narbel, Swiss biologist and politician (d. 2010) February 8 – Fred Blassie, American professional wrestler, novelty singer (Pencil Neck Geek) (d. 2003) February 12 – Julian Schwinger, American physicist, Nobel Prize laureate (d. 1994) February 14 – William L. Snyder, American film producer (d. 1998) February 15 – Smilja Avramov, Serbian academic, authority and educator in international law (d. 2018) February 19 – Fay McKenzie, American silent film actress (d. 2019) February 22 Don Pardo, American television announcer (Saturday Night Live) (d. 2014) Robert Pershing Wadlow, American tallest man record-holder (d. 1940) February 25 Barney Ewell, American athlete (d. 1996) Miguel Gallastegui, Spanish pelotari (d. 2019) Bobby Riggs, American tennis player (d. 1995) February 26 Herbert Blaize, 6th Prime Minister of Grenada (d. 1989) Lloyd Geering, New Zealand theologian[33] Theodore Sturgeon, American writer (d. 1985) February 28 – Alfred Burke, English actor (d. 2011) João Goulart James Tobin Marguerite Chapman Elaine de Kooning Frederick Reines Pearl Bailey March 1 Roger Delgado, British actor (d. 1973) João Goulart, 24th President of Brazil (d. 1976) March 3 Arthur Kornberg, American biochemist, recipient of the Nobel Prize in Physiology or Medicine (d. 2007) Fritz Thiedemann, German equestrian (d. 2000) March 4 – Margaret Osborne duPont, American female tennis player (d. 2012) March 5 – James Tobin, American economist, Nobel Memorial Prize laureate (d. 2002)[34] March 9 Marguerite Chapman, American actress (d. 1999) George Lincoln Rockwell, American Nazi leader (d. 1967) Mickey Spillane, American writer (d. 2006)[35] March 10 Günther Rall, German ace fighter pilot (d. 2009) March 12 Elaine de Kooning, American artist (d. 1989)[36] William E. Nichol, American politician from Nebraska (d. 2006) March 16 – Frederick Reines, American physicist, Nobel Prize laureate (d. 1998)[37] March 17 – Viviane Gauthier, Haitian dancer (d. 2017) March 22 – Cheddi Jagan, 4th President of Guyana (d. 1997) March 23 Kazu Naoki, Japanese soccer player (d. 1940s) Émile Derlin Zinsou, President of Benin (d. 2016) March 28 – Gonzalo Facio Segreda, Costa Rican lawyer, politician, and diplomat (d. 2018) March 29 Pearl Bailey, African-American singer, actress (d. 1990) Sam Walton, founder of Wal-Mart (d. 1992) William Holden Kai Siegbahn Fanny Blankers-Koen April 1 – Diarmuid Larkin, Irish artist and art educationist (d. 1989) April 6 Alfredo Ovando Candía, 48th President of Bolivia (d. 1982) George Corones, Australian Masters swimmer (d. 2020) April 7 – Bobby Doerr, American baseball player (d. 2017) April 8 – Betty Ford, First Lady of the United States (d. 2011) April 9 – Jørn Utzon, Danish architect (d. 2008) April 10 – H. S. Doreswamy, Indian activist, journalist (d. 2021) April 11 – Jean-Claude Servan-Schreiber, French journalist, politician (d. 2018) April 14 – Mary Healy, American actress, variety entertainer and singer (d. 2015)[38] April 16 – Spike Milligan, Irish comedian (d. 2002) April 17 William Holden, American actor (d. 1981) Anne Shirley, American actress (d. 1993) April 18 Gabriel Axel, Danish film director (d. 2014) Shinobu Hashimoto, Japanese screenwriter (d. 2018) April 20 – Kai Siegbahn, Swedish physicist, Nobel Prize laureate (d. 2007)[39] April 26 – Fanny Blankers-Koen, Dutch athlete (d. 2004) April 28 Karl-Eduard von Schnitzler, East German journalist, host of the television show Der schwarze Kanal (d. 2001) Rodger Young, United States Army soldier, remembered in the song "The Ballad of Rodger Young" (d. 1943) April 29 – Nils Östensson, Swedish Olympic cross-country skier (d. 1949) Mike Wallace Richard Feynman Eddy Arnold Birgit Nilsson Yasuhiro Nakasone Martin Lundstrom May 1 Jack Paar, American television show host (The Tonight Show) (d. 2004)[40] Li Yaowen, Chinese politician, general and diplomat (d. 2018) May 4 Kakuei Tanaka, 40th Prime Minister of Japan (d. 1993) Ana Enriqueta Terán, Venezuelan poet (d. 2017) May 6 Henrietta Boggs, Costa Rican-American author, journalist and activist (d. 2020) Zayed bin Sultan Al Nahyan, 1st President of the United Arab Emirates (d. 2004) May 9 Orville Freeman, American politician (d. 2003) Mike Wallace, American journalist (d. 2012) May 11 – Richard Feynman, American physicist, Nobel Prize laureate (d. 1988)[41] May 12 – Julius Rosenberg, American-born Soviet spy (d. 1953) May 15 Eddy Arnold, American country music singer (d. 2008) Joseph Wiseman, Canadian actor (d. 2009)[42] May 16 – Wilf Mannion, English footballer (d. 2000)[43] May 17 – Birgit Nilsson, Swedish soprano (d. 2005)[44] May 19 – Abraham Pais, Dutch-born American physicist (d. 2000) May 20 – Edward B. Lewis, American geneticist, recipient of the Nobel Prize in Physiology or Medicine (d. 2004) May 23 Frank Mancuso, American major league baseball player, politician (d. 2007) Naomi Replansky, American poet (d. 2023) May 27 – Yasuhiro Nakasone, 45th Prime Minister of Japan (d. 2019) May 28 Norbert Franck, Luxembourgish swimmer (d. 2006) Johnny Wayne, Canadian comedian (d. 1990) May 30 – Martin Lundström, Swedish Olympic cross-country skier (d. 2016) May 31 – Margaret Todd, Canadian female golfer (d. 2019) Franco Modigliani June 2 – Kathryn Tucker Windham, American writer, storyteller (d. 2011) June 6 – Edwin G. Krebs, American biochemist, recipient of the Nobel Prize in Physiology or Medicine (d. 2009) June 8 – Robert Preston, American actor (The Music Man) (d. 1987) June 9 – John Hospers, American philosopher (d. 2011) June 10 – Patachou, French singer (d. 2015) June 11 – Hugo Scheltema, Dutch diplomat (d. 1996) June 15 – François Tombalbaye, 1st President of Chad (d. 1975) June 17 Derek Barber, Baron Barber of Tewkesbury, British life peer (d. 2017) Ajahn Chah Subaddho, Buddhist teacher (d. 1992) Raúl Padilla (alias El Chato), Mexican actor (d. 1994) June 18 Jerome Karle, American chemist, Nobel Prize laureate (d. 2013) Franco Modigliani, Italian-born economist, Nobel Memorial Prize laureate (d. 2003) Ángel Martín Taboas, Puerto Rican-American politician (d. 2023) June 21 Allan Lindberg, Swedish pole vaulter (d. 2004) Tibor Szele, Hungarian mathematician (d. 1955) Josephine Webb, American engineer (d. 2017) June 22 Cicely Saunders, English Anglican nurse, social worker, physician and writer (d. 2005)[45] Yeoh Ghim Seng, Singaporean politician, acting President of Singapore (d. 1993) June 24 Myroslav Ivan Lubachivsky, Ukrainian Catholic bishop (d. 2000) Yong Nyuk Lin, Singaporean politician (d. 2012) June 26 Ellen Liiger, Estonian actress (d. 1987) Leo Rosner, Polish-born Austrian Jewish musician (d. 2008) June 27 Willy Breinholst, Danish humorist, writer (d. 2009) Adolph Kiefer, American Olympic swimmer (d. 2017)[46] June 29 – Heini Lohrer, Swiss ice hockey player (d. 2011) June 30 – Jackie Roberts, Welsh footballer (d. 2001) Ingmar Bergman Bertram Brockhouse Nelson Mandela Paul D. Boyer July 1 Ahmed Deedat, South African writer, public speaker (d. 2005) Pedro Yap, Filipino lawyer (d. 2003) July 2 Athos Bulcão, Brazilian painter, sculptor (d. 2008) Indumati Bhattacharya, Indian politician (d. 1990) July 3 – Lorenzo Robledo, Spanish actor (d. 2006) July 4 King Tāufa'āhau Tupou IV of Tonga (d. 2006) Alec Bedser, English cricketer (d. 2010) Eric Bedser, English cricketer (d. 2006) July 5 Zakaria Mohieddin, Egyptian general, politician (d. 2012) Nikos Papatakis, Greek Ethiopian-born naturalised French filmmaker (d. 2010) Miguel Ángel Sanz Bocos, Spanish fighter pilot (d. 2018) July 6 Sebastian Cabot, English actor (d. 1977) Francisco Moncion, Dominican-American dancer, charter member of New York City Ballet (d. 1995) July 7 – Jing Shuping, Chinese businessman (d. 2009) July 8 Paul B. Fay, American businessman, soldier, and diplomat, 12th United States Secretary of the Navy (d. 2009) Oluf Reed-Olsen, Norwegian resistance member, pilot (d. 2002) July 9 – Jarl Wahlström, Salvation Army general (d. 1999) July 12 – Mary Glen-Haig, British Olympic fencer (d. 2014) July 13 Alberto Ascari, Italian racing driver (d. 1955) Ted Oldfield, English footballer (d. 2006) July 14 T. M. Aluko, Nigerian writer (d. 2010)[47] Ingmar Bergman, Swedish film director (d. 2007[48]) Jay Wright Forrester, American computer scientist (d. 2016)[49] July 15 Paddy Bassett, New Zealand scientist (d. 2019) Bertram Brockhouse, Canadian physicist, Nobel Prize laureate (d. 2003) Brenda Milner, Canadian neuropsychologist July 16 Bayani Casimiro, Filipino dancer and actor (d. 1989) Pituka de Foronda, Spanish actress (d. 1999) July 17 – Carlos Manuel Arana Osorio, 35th President of Guatemala (d. 2003) July 18 Lia Dorana, Dutch comedian, actress (d. 2010) Nelson Mandela, 1st President of South Africa and recipient of the Nobel Peace Prize (d. 2013)[50] July 20 – Auður Laxness, Icelandic writer, craftsperson (d. 2012) July 21 – Elsa Kobberstad, Norwegian schoolteacher, politician (d. 2007) July 22 – Lila Zali, Georgian-born American prima ballerina (d. 2003) July 24 Antonio Candido, Brazilian literary critic, sociologist (d. 2017) Ruggiero Ricci, Italian-born violinist (d. 2012) July 27 – Leonard Rose, American cellist (d. 1984) July 28 – Penaia Ganilau, 1st President of Fiji (d. 1993) July 29 – Edwin O'Connor, American novelist, Pulitzer Prize for Fiction winner (d. 1968) July 31 Vicente Almeida d'Eça, Portuguese colonial administrator (d. 2018) Paul D. Boyer, American chemist, Nobel Prize laureate (d. 2018) Hank Jones, American pianist (d. 2010)[51] Bruria Kaufman Frederick Sanger Shankar Dayal Sharma Leonard Bernstein Katherine Johnson Aslam Khan Alejandro Agustín Lanusse August 1 Artur Brauner, German film producer and entrepreneur (d. 2019) Zhou Xuan, Chinese singer, actress (d. 1957) August 2 – Dada Vaswani, Indian spiritual leader (d. 2018) August 3 – Cheng Kaijia, Chinese nuclear physicist and engineer (d. 2018) August 4 – Noel Willman, Irish actor (d. 1988) August 5 Kondapalli Koteswaramma, Indian communist leader, feminist, revolutionary and writer (d. 2018) Betty Oliphant, co-founder of National Ballet of Canada (d. 2004) August 12 – Guy Gibson, British bomber pilot, leader of the "Dam Busters" raid (d. 1944) August 13 Noor Hassanali, 2nd President of Trinidad and Tobago (d. 2006) Frederick Sanger, English biochemist, double Nobel Prize laureate (d. 2013) August 19 – Shankar Dayal Sharma, 9th President of India (d. 1999) August 20 – Crystal Bennett, British archaeologist, pioneering researcher on Jordan (d. 1987) August 21 – Bruria Kaufman, American-born Israeli physicist (d. 2010) August 22 Said Mohamed Djohar, President of the Comoros (d. 2006) Martin Pope, American physical chemist (d. 2022) August 23 – Bernard Fisher, American surgeon (d. 2019) August 25 – Leonard Bernstein, American composer, conductor (d. 1990) August 26 Katherine Johnson, African-American physicist, space scientist and mathematician (d. 2020)[52] Maria Isaura Pereira de Queiróz, Brazilian sociologist (d. 2018) August 27 Aslam Khan, British Indian-born military officer, led his troops during World War II in capturing Kennedy Peak (Myanmar), which the Americans had failed to conquer. For this achievement, he was awarded the Military Cross by Field Marshal Auchinleck (d. 1994)[53] Chang Yun Chung, Chinese-born billionaire shipping magnate (d. 2020) Jelle Zijlstra, Dutch politician, Prime Minister of the Netherlands from 1966 to 1967 (d. 2001) August 28 – Alejandro Agustín Lanusse, 37th President of Argentina (d. 1996) August 29 – Clemens C. J. Roothaan, Dutch physicist (d. 2019) August 30 – Ted Williams, American baseball player (d. 2002) August 31 – Alan Jay Lerner, American lyricist, librett

are later overturned on appeal. 1989 – Space Shuttle Atlantis launches on mission STS-30 to deploy the Venus-bound Magellan space probe.[22] 1990 – Latvia declares independence from the Soviet Union. 1994 – Israeli Prime Minister Yitzhak Rabin and PLO leader Yasser Arafat sign a peace accord, granting self-rule in the Gaza Strip and Jericho. 1998 – A federal judge in Sacramento, California, gives "Unabomber" Theodore Kaczynski four life sentences plus 30 years after Kaczynski accepts a plea agreement sparing him from the death penalty. 2000 – Ken Livingstone becomes the first Mayor of London (an office separate from that of the Lord Mayor of London). 2002 – One hundred three people are killed and 51 are injured in a plane crash near Mallam Aminu Kano International Airport in Kano, Nigeria.[23] 2007 – Greensburg, Kansas is almost completely destroyed by the 2007 Greensburg tornado, a 1.7-mile wide EF5 tornado. It was the first-ever tornado to be rated as such with the new Enhanced Fujita scale. 2014 – Three people are killed and 62 injured in a pair of bombings on buses in Nairobi, Kenya.[24] 2019 – The inaugural all-female motorsport series, W Series, takes place at Hockenheimring. The race was won by Jamie Chadwick, who would go on to become the inaugural season's champion.[25] 2023 – Nine people are killed and thirteen injured in a spree shooting in Mladenovac and Smederevo, Serbia. It is the second mass shooting in the country in two days.[26][27][28] 1006 – Khwaja Abdullah Ansari, Persian mystic and poet (died 1088) 1559 – Alice Spencer, English noblewoman (died 1637) 1634 – Katherine Ferrers, English aristocrat and heiress (died 1660) 1649 – Chhatrasal, Indian ruler (died 1731) 1655 – Bartolomeo Cristofori, Italian instrument maker, invented the piano (died 1731) 1677 – Françoise-Marie de Bourbon, French noblewoman (died 1749) 1715 – Richard Graves, English minister and author (died 1804) 1733 – Jean-Charles de Borda, French mathematician, physicist, and sailor (died 1799) 1752 – John Brooks, American soldier and politician, 11th Governor of Massachusetts (died 1825) 1757 – Manuel Tolsá, Spanish sculptor and first director of the Academy of San Carlos in Mexico City (died 1816) 1767 – Tyagaraja, Indian composer (died 1847) 1770 – François Gérard, French painter (died 1837) 1772 – Friedrich Arnold Brockhaus, German publisher (died 1823) 1796 – Horace Mann, American educator and politician (died 1859) 1796 – William Pennington, American lawyer and politician, 13th Governor of New Jersey, 23rd Speaker of the United States House of Representatives (died 1862) 1796 – William H. Prescott, American historian and scholar (died 1859) 1820 – Julia Gardiner Tyler, American wife of John Tyler, 11th First Lady of the United States (died 1889) 1820 – John Whiteaker, American soldier, judge, and politician, 1st Governor of Oregon (died 1902) 1822 – Charles Boucher de Boucherville, Canadian physician and politician, 3rd Premier of Quebec (died 1915) 1825 – Thomas Henry Huxley, English biologist, anatomist, and academic (died 1895) 1825 – Augustus Le Plongeon, English-American historian, photographer, and academic (died 1908) 1826 – Frederic Edwin Church, American painter (died 1900) 1827 – John Hanning Speke, English soldier and explorer (died 1864) 1843 – Bianka Blume, German opera singer (died 1896)[29] 1851 – Thomas Dewing, American painter (died 1938) 1852 – Alice Liddell, English model (died 1934) 1883 – Wang Jingwei, Chinese politician (died 1944) 1884 – Richard Baggallay, English army officer and cricketer (died 1975)[30] 1887 – Andrew Dasburg, French-American painter (died 1979) 1889 – Francis Spellman, American cardinal (died 1967)[31] 1890 – Franklin Carmichael, Canadian painter (died 1945) 1902 – Ronnie Aird, English cricketer and administrator (died 1986) 1903 – Luther Adler, American actor (died 1984) 1905 – Al Dexter, American country singer-songwriter and guitarist (died 1984) 1907 – Lincoln Kirstein, American soldier and playwright, co-founded the New York City Ballet (died 1996) 1907 – Walter Walsh, American target shooter and FBI agent (died 2014) 1913 – Princess Katherine of Greece and Denmark (died 2007) 1914 – Maedayama Eigorō, Japanese sumo wrestler, the 39th Yokozuna (died 1971) 1916 – Jane Jacobs, American-Canadian journalist, author, and activist (died 2006) 1916 – Richard Proenneke, American soldier, carpenter, and meteorologist (died 2003) 1917 – Nick Joaquin, Filipino writer, journalist and historian (died 2004) 1918 – Kakuei Tanaka, Japanese soldier and politician, 64th Prime Minister of Japan (died 1993) 1921 – Edo Murtić, Croatian painter, sculptor, and illustrator (died 2005) 1922 – Eugenie Clark, American biologist and academic (died 2015) 1923 – Eric Sykes, British actor and comedian (died 2012) 1925 – Maurice R. Greenberg, American businessman and philanthropist 1928 – Maynard Ferguson, Canadian trumpet player and bandleader (died 2006) 1928 – Hosni Mubarak, Egyptian air marshal and politician, 4th President of Egypt (died 2020) 1928 – Betsy Rawls, American golfer (died 2023) 1929 – Manuel Contreras, Chilean general (died 2015) 1929 – Audrey Hepburn, Belgian-British actress and humanitarian (died 1993) 1930 – Katherine Jackson, matriarch of the Jackson family 1932 – Harlon Hill, American football player and coach (died 2013) 1937 – Ron Carter, American bassist and educator 1937 – Dick Dale, American surf-rock guitarist, singer, and songwriter (died 2019) 1938 – Carlos Monsiváis, Mexican journalist, author, and critic (died 2010) 1939 – Amos Oz, Israeli journalist and author (died 2018) 1940 – Robin Cook, American physician and author 1941 – George Will, American journalist and author 1943 – Georgi Asparuhov, Bulgarian footballer (died 1971) 1944 – Russi Taylor, American voice actress (died 2019) 1945 – Robert Machray, American actor (died 2025)[32][33] 1946 – John Barnard, English car designer 1946 – Gary Bauer, American political activist 1946 – John Watson, British race car driver 1948 – King George Tupou V of Tonga, (died 2012) 1951 – Colin Bass, English bass player, songwriter, and producer 1951 – Colleen Hanabusa, American lawyer and politician 1951 – Jackie Jackson, American singer-songwriter and dancer[34] 1952 – Belinda Green, Australian beauty queen and 1972 Miss World 1953 – Pia Zadora, American actress and singer 1954 – Ryan Cayabyab, Filipino pianist, composer, and conductor 1956 – Ken Oberkfell, American baseball player and coach 1957 – Kathy Kreiner, Canadian skier 1958 – Keith Haring, American painter (died 1990) 1958 – Caroline Spelman, English politician, Secretary of State for Environment, Food and Rural Affairs 1959 – Randy Travis, American singer-songwriter, guitarist, and actor 1960 – Werner Faymann, Austrian politician, 28th Chancellor of Austria 1961 – Jay Aston, English singer-songwriter and dancer 1967 – Kate Garraway, English journalist 1967 – Ana Gasteyer, American actress and singer 1970 – Will Arnett, Canadian actor and producer 1970 – Dawn Staley, American basketball player 1972 – Mike Dirnt, American bass player and songwriter 1972 – Chris Tomlin, American singer-songwriter[35] 1973 – Guillermo Barros Schelotto, Argentinian footballer and coach 1973 – John Madden, Canadian ice hockey player and coach 1974 – Tony McCoy, Northern Irish jockey and sportscaster 1975 – Kimora Lee Simmons, American model[36] 1978 – Erin Andrews, American sportscaster and journalist 1978 – Igor Biscan, Croatian footballer and manager 1978 – James Harrison, American football player[37] 1979 – Lance Bass, American singer, dancer, and producer 1979 – Lesley Vainikolo, Tongan rugby player 1980 – Andrew Raycroft, Canadian ice hockey player 1981 – Eric Djemba-Djemba, Cameroon footballer 1981 – Ruth Negga, Ethiopian-Irish actress[38][39] 1981 – Dallon Weekes, American singer-songwriter and musician 1983 – Derek Roy, Canadian ice hockey player 1984 – Brad Maddox, American wrestler and referee 1985 – Ravi Bopara, English cricketer 1985 – Fernandinho, Brazilian footballer 1985 – Jamie Adenuga, English MC and rapper 1986 – Devan Dubnyk, Canadian ice hockey player 1986 – George Hill, American basketball player 1987 – Cesc Fàbregas, Spanish footballer and manager 1987 – Jorge Lorenzo, Spanish motorcycle racer 1988 – Radja Nainggolan, Belgian footballer 1989 – Rory McIlroy, Northern Irish golfer 1989 – James van Riemsdyk, American ice hockey player 1991 – Brianne Jenner, Canadian women's ice hockey player 1992 – Victor Oladipo, American basketball player 1994 – Abi Masatora, Japanese sumo wrestler 1994 – Joseph Tapine, New Zealand rugby league player 1998 – Alexander O'Connor, English musician[40] 408 – Venerius, archbishop of Milan 784 – Arbeo, bishop of Freising 1003 – Herman II, duke of Swabia 1038 – Gotthard of Hildesheim, German bishop (born 960) 1406 – Coluccio Salutati, chancellor of Florence (born 1331) 1436 – Engelbrekt Engelbrektsson, Swedish rebel leader (27 April O.S.).[41] 1471 – Edward of Westminster, Prince of Wales, son and heir of Henry VI of England (born 1453) 1483 – George Neville, Duke of Bedford (born 1457) 1506 – Husayn Mirza Bayqara, Timurid ruler of Herat (born 1438) 1519 – Lorenzo de' Medici, duke of Urbino (born 1492)[42] 1535 – John Houghton, Carthusian monk and saint 1562 – Lelio Sozzini, Italian Protestant theologian (born 1525) 1566 – Luca Ghini, Italian physician and botanist (born 1490) 1571 – Pierre Viret, Swiss theologian and reformer (born 1511) 1604 – Claudio Merulo, Italian organist and composer (born 1533) 1605 – Ulisse Aldrovandi, Italian naturalist (born 1522) 1615 – Adriaan van Roomen, Flemish priest and mathematician (born 1561) 1626 – Arthur Lake, English bishop and scholar (born 1569) 1677 – Isaac Barrow, English mathematician and theologian (born 1630) 1684 – John Nevison, English criminal (born 1639) 1729 – Louis Antoine de Noailles, French cardinal (born 1651) 1734 – James Thornhill, English painter and politician (born 1675) 1737 – Eustace Budgell, English journalist and politician (born 1686) 1774 – Anthony Ulrich of Brunswick, Prussian nobleman (born 1714) 1776 – Jacques Saly, French painter and sculptor (born 1717) 1790 – Matthew Tilghman, American politician (born 1718) 1799 – Tipu, ruler of Mysore (born 1750) 1811 – Nikolay Kamensky, Russian general (born 1776) 1816 – Samuel Dexter, American lawyer and politician, 4th United States Secretary of War, 3rd United States Secretary of the Treasury (born 1761) 1824 – Joseph Joubert, French author (born 1754) 1826 – Sebastián Kindelán y O'Regan, colonial governor of East Florida, Santo Domingo and Cuba (born 1757)[43] 1839 – Denis Davydov, Russian general and poet (born 1784) 1859 – Joseph Diaz Gergonne, French mathematician and philosopher (born 1771) 1880 – Edward Clark, American lawyer and politician, 8th Governor of Texas (born 1815) 1901 – John Jones Ross, Canadian lawyer and politician, 7th Premier of Quebec (born 1831) 1903 – Gotse Delchev, Macedonian Bulgarian revolutionary IMRO (born 1872) 1912 – Nettie Stevens, American geneticist credited with discovering sex chromosomes (born 1861)[44] 1916 – Ned Daly, Irish rebel commander (Easter Rising) (born 1891) 1916 – John Murray, Australian politician, 23rd Premier of Victoria (born 1851) 1916 – Willie Pearse, Irish rebel (born 1881) 1916 – Joseph Plunkett, Irish rebel and writer (born 1887) 1919 – Milan Rastislav Štefánik, Slovak general and politician (born 1880) 1922 – Viktor Kingissepp, Estonian politician (born 1888) 1923 – Ralph McKittrick, American golfer and tennis player (born 1877) 1924 – E. Nesbit, English author and poet (born 1858) 1937 – Gina Oselio, Norwegian opera singer (born 1858).[45] 1938 – Kanō Jigorō, Japanese founder of judo (born 1860) 1938 – Carl von Ossietzky, German journalist and activist, Nobel Prize laureate (born 1889) 1941 – Chris McKivat, Australian rugby player and coach (born 1880) 1945 – Fedor von Bock, German field marshal (born 1880) 1953 – Alexandre Pharamond, French rugby player (born 1876)[46] 1955 – George Enescu, Romanian pianist, composer, and conductor (born 1881) 1964 – Karl Robert Pusta, Estonian politician, 4th Estonian Minister of Foreign Affairs (born 1883) 1969 – Osbert Sitwell, English-Italian author and poet (born 1892) 1971 – William Brown Meloney, writer and theatrical producer (born 1902)[47] 1972 – Father Chrysanthus, Dutch arachnologist (born 1905)[48] 1972 – Edward Calvin Kendall, American chemist and academic, Nobel Prize laureate (born 1886) 1973 – Jane Bowles, American author and playwright (born 1917) 1975 – Moe Howard, American actor, singer, and screenwriter (born 1897) 1976 – Frank Strahan, Australian public servant (born 1886) 1980 – Josip Broz Tito, Yugoslav field marshal and politician, 1st President of Yugoslavia (born 1892) 1981 – C. Loganathan, Sri Lankan banker (born 1913) 1983 – Nino Sanzogno, Italian conductor and composer (born 1911) 1984 – Diana Dors, English actress (born 1931) 1985 – Fikri Sönmez, Turkish tailor and politician (born 1938) 1985 – Clarence Wiseman, English-Canadian 10th General of The Salvation Army (born 1907) 1987 – Paul Butterfield, American singer and harmonica player (born 1942)[49] 1987 – Cathryn Damon, American actress (born 1930) 1988 – Lillian Estelle Fisher, American historian of Spanish America (born 1891) 1990 – Emily Remler, American guitarist (born 1957) 1991 – Mohammed Abdel Wahab, Egyptian singer-songwriter and mandolin player (born 1902) 1992 – Gregor Mackenzie, Scottish politician (born 1927) 1993 – France Štiglic, Slovenian film director and screenwriter (born 1919) 1995 – Connie Wisniewski, American baseball player (born 1922)[50] 2000 – Hendrik Casimir, Dutch physicist and academic (born 1909) 2001 – Bonnie Lee Bakley, American model, wife of Robert Blake (born 1956) 2004 – David Reimer, Canadian man, born male but reassigned female and raised as a girl after a botched circumcision (born 1965)[51] 2005 – David Hackworth, American colonel and journalist (born 1930) 2008 – Fred Baur, American chemist and founder of Pringles (born 1918)[52] 2009 – Dom DeLuise, American actor, director, and producer (born 1933) 2011 – Sammy McCrory, Northern Irish footballer (born 1924) 2012 – Mort Lindsey, American pianist, composer, and conductor (born 1923) 2012 – Bob Stewart, American television producer, founded Stewart Tele Enterprises (born 1920) 2012 – Adam Yauch, American rapper and director (born 1964) 2012 – Rashidi Yekini, Nigerian footballer (born 1963) 2013 – Otis Bowen, American physician and politician, 44th Governor of Indiana (born 1918) 2013 – Christian de Duve, English-Belgian cytologist and biochemist, Nobel Prize laureate (born 1917) 2013 – Javier Diez Canseco, Peruvian sociologist and politician (born 1948) 2013 – Mario Machado, Chinese-American journalist and actor (born 1935) 2013 – Morgan Morgan-Giles, English admiral and politician (born 1914) 2013 – César Portillo de la Luz, Cuban guitarist and composer (born 1922) 2014 – Dick Ayers, American author and illustrator (born 1924) 2014 – Elena Baltacha, Ukrainian-Scottish tennis player (born 1983) 2014 – Edgar Cortright, American scientist and engineer (born 1923) 2014 – Helga Königsdorf, German physicist and author (born 1938) 2014 – Ross Lonsberry, Canadian-American ice hockey player (born 1947) 2014 – Jean-Paul Ngoupandé, Central African politician, Prime Minister of the Central African Republic (born 1948) 2015 – William Bast, American screenwriter and author (born 1931) 2015 – Ellen Albertini Dow, American actress (born 1913) 2015 – Marv Hubbard, American football player (born 1946)[53] 2016 – Jean-Baptiste Bagaza, Burundian politician (born 1946) 2020 – Don Shula, American football player and coach (born 1930)[54] 2020 – Greg Zanis, American carpenter and activist (born 1950)[55] 2021 – Nick Kamen, English model, songwriter (born 1962)[56] 2024 – Ron Kavana, Irish singer, songwriter, guitarist and band leader (born 1950)[57] 2024 – Frank Stella, American painter (born 1936)[58] Anti-Bullying Day (United Nations) Bird Day (United States) Cassinga Day (Namibia) Christian feast day: Blessed Ceferino Giménez Malla Blessed Michał Giedroyć English Saints and Martyrs of the Reformation Era (Church of England) F. C. D. Wyneken (Lutheran Church–Missouri Synod) Florian José María Rubio Judas Cyriacus Monica of Hippo (1960 Roman Catholic Calendar) Sacerdos of Limoges Venerius of Milan May 4 (Eastern Orthodox liturgics) Coal Miners Day (India)[59] Death of Milan Rastislav Štefánik Day (Slovakia) Greenery Day (Japan) International Firefighters' Day May Fourth Movement commemorations: Literary Day (Republic of China) Youth Day (China) Remembrance Day for Martyrs and Disabled (Afghanistan) Remembrance of the Dead (Netherlands) Restoration of Independence Day (Latvia) Star Wars Day (International observance) World Give Day Youth Day (Fiji) ^ Flannery, John M. (2013). The Mission of the Portuguese Augustinians to Persia and Beyond (1602-1747). Lieden: Brill. p. 40. ISBN 9789004243828. ^ Bray, Gerald (2018). "On the Truth of Holy Scripture (1377-1378) John Wycliffe (c. 1328-1384)". In Kapic, Kelly M.; Madueme, Hans (eds.). Reading Christian Theology in the Protestant Tradition. 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