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Kinetic and potential energy example problems with solutions

Energy is the capacity to do work. The unit of energy is J (Joule) which is also kg m²/s² (kilogram meter squared per second squared) Energy can be in many forms! Here we look at Potential Energy (PE) and Kinetic Energy (KE). Potential Energy and Kinetic Energy A hammer: when raised up has potential energy (the energy of position or state) when falling down has kinetic energy (the energy of motion) a raised hammer has PE due to gravity. fuel and explosives have Chemical PE a coiled spring or a drawn bow also have PE due to their state A moving car has a lot of kinetic energy From PE to KE These skydivers have potential energy due to being high up. After they jump this potential energy gets converted into kinetic energy (and heat) as they speed up. Pendulum For a good example of PE and KE have a play with a pendulum. Gravitational Potential Energy When the PE is due to an objects height then: PE due to gravity = m g h Where: m is the objects mass (kg) g is the "gravitational field strength" of 9.8 m/s² near the Earth's surface h is height (m) Example: This 2 kg hammer is 0.4 m up. What is it's PE? PE = m g h = 2 kg × 9.8 m/s² × 0.4 m = 7.84 kg m²/s² = 7.84 J Kinetic Energy The formula is: KE = ½ m v² Where m is the object's mass (kg) v is the object's speed (m/s) Example: What is the KE of a 1500 kg car going at suburban speed of 14 m/s (about 50 km/h or 30 mph)? KE = ½ m v² KE = ½ × 1500 kg × (14 m/s)² KE = 147,000 kg m²/s² KE = 147 kJ Let's double the speed! Example: The same car is now going at highway speed of 28 m/s (about 100 km/h or 60 mph)? KE = ½ m v² KE = ½ × 1500 kg × (28 m/s)² KE = 588,000 kg m²/s² KE = 588 kJ Wow! that is a big increase in energy! Highway speed is way more dangerous. Double the speed and the KE increases by four times. Very important to know A 1 kg meteorite strikes the Moon at 11 km/s. How much KE is that? KE = ½ m v² KE = ½ × 1 kg × (11,000 m/s)² KE = 60,500,000 J KE = 60.5 MJ That is 100 times the energy of a car going at highway speed. From PE to KE When falling, an object's PE due to gravity converts into KE and also heat due to air resistance. Let's drop something! Example: We drop this 0.1 kg apple 1 m. What speed does it hit the ground with? At 1 m above the ground it's Potential Energy is PE = m g h PE = 0.1 kg × 9.8 m/s² × 1 m PE = 0.98 kg m²/s² Ignoring air resistance (which is small for this little drop anyway) that PE gets converted into KE: KE = ½ m v² Swap sides and rearrange: ½ m v² = KE v² = 2 × KE / m v = √(2 × KE / m) Now put PE into KE and we get: v = √(2 × 0.98 kg m²/s² / 0.1 kg) v = √(19.6 m²/s²) v = 4.427... m/s Note: for velocity we can combine the formulas like this: Velocity from KE: v = √(2 × KE / m) Put in formula for PE: v = √(2 × mgh / m) Cancel m/m: v = √(2gh) The mass does not matter! It is all about height and gravity. For our earlier example: v = √(2gh) v = √(2 × 9.8 m/s² × 1 m) v = 4.427... m/s Summary Energy is the ability to do work Potential Energy (PE) is stored energy due to position or state PE due to gravity = m g h Kinetic Energy (KE) is energy of motion KE = ½ m v² Copyright © 2020 MathsIsFun.com When work is done by a force on an object. It acquires energy, it can be any form. Energy can take on many forms and can be converted from one form to another form. Potential energy, electric potential energy, kinetic energy, etc. are some examples of different types of energy. Kinetic energy comes when the object starts moving. This energy is due to motion. Although this energy is due to motion, this energy is not created. It is usually converted from one type of energy to another type. Let's look at this concept in detail. Kinetic EnergyIf an object is stationary, and we want to put that object into motion. We need to apply force. Any type of acceleration requires some force. When this force is applied, work is done on the object. When the work is done on an object, this means energy is getting transferred to the object is one form or another. Force can be removed once the object is in motion, but till the time force was applied on the object. The work that was done during that time is converted into energy. Kinetic energy is the energy an object acquires by virtue of its motion. This energy can be transferred from one object to another. For example, a moving ball hitting a stationary ball might cause the other ball to move. In this situation, some kinetic energy of the ball is transferred to another ball. Formula of Kinetic Energy To calculate the kinetic energy of the object, let's consider a scenario where a force F, is acting on an object of mass M. In this case, the object starts moving with the acceleration "a" and covers a distance of "d". Work done in this case will be, W = F.d=W = m.a.dThe acceleration "a" can be replaced using an equation of motion. v² = u² + 2a.d=v² - u² = 2a.d= dSubstituting the value of "d" in the equation, W = m.a.d= W = =W = =W = So, this whole work done is converted into the K.E of the object. In case, initial velocity u = 0, K.E = One can also say, the network work done on the system is equal to the change in kinetic energy of the object. Note: 1. Kinetic energy depends on the velocity of the object squared. This means, when th velocity of the object is doubled, its kinetic energy becomes four times. 2, K.E must always have zero or positive values. 3. Kinetic energy is a scalar quantity, and it is expressed in Joules. Sample ProblemsQuestion 1: A ball has a mass of 2Kg, suppose it travels at 10m/s. Find the kinetic energy possessed by it. Answer: Given: m = 2Kg, and v = 10m/s The KE is given by, K.E = KE = = K.E = = K.E = 100JQuestion 2: A ball has a mass of 10Kg, suppose it travels at 100m/s. Find the kinetic energy possessed by it. Answer: Given: m = 10Kg, and v = 100m/s The KE is given by, K.E = KE = = K.E = = K.E = 50000JQuestion 3: A spaceship has a mass of 20000Kg, suppose it travels at 10m/s. Find the kinetic energy possessed by it. Answer: Given: m = 20000Kg, and v = 10m/s The KE is given by, K.E = KE = = K.E = = K.E = 100JQuestion 4: Work done by a force on a moving object is 100J. It was traveling at a speed of 2 m/s. Find the new speed of the object if the mass of the object is 2Kg.Answer: Given: W = 100JWork done by the force is equal to the change in kinetic energy. W = Given, u = 2 m/s and v = ?, m = 2kg. Plugging the values in the given equation, W = = =Question 5: Work done by a force on a moving object is -50J. It was traveling at a speed of 10m/s. Find the new speed of the object if the mass of the object is 2Kg.Answer: Given: W = -50JWork done by the force is equal to the change in kinetic energy. W = Given, u = 10m/s and v = ?, m = 2kg. Plugging the values in the given equation, W = = =The speed is decreased because the work done was negative. This means that the force was acting opposite to the block and velocity was decreased. Question 6: Suppose a 1000Kg was traveling at a speed of 10m/s. Now, this mass transfers all its energy to a mass of 10Kg. What will be the velocity of the 10Kg mass after being hit by it? Answer: KE is given by the formula,K.E = KE of the heavier object M =1000Kg and v = 10m/s K.E = = K.E = =K.E = 50,000J Now this energy is transferred to another ball. m = 10Kg and v = ?50,000 = = 10,000 = v²= v = 100 m/sQuestion 7: Suppose a 10Kg was traveling at a speed of 100m/s. Now, this mass transfers all its energy to a mass of 20Kg. What will be the velocity of the 20Kg mass after being hit by it? Answer: KE is given by the formula,K.E = KE of the heavier object M =10Kg and v = 100m/s K.E = = K.E = =K.E = 50,000J Now this energy is transferred to another ball. m = 20Kg and v = ?50,000 = = 5000 = v²= v = 50√2 m/sQuestion 8: Suppose a 10Kg was traveling at a speed of 100m/s. Now, this mass transfers all its energy to a mass of 20Kg. What will be the velocity of the 20Kg mass after being hit by it? Answer: KE is given by the formula,K.E = KE of the heavier object M =10Kg and v = 100m/s K.E = = K.E = =K.E = 50,000J Now this energy is transferred to another ball. m = 20Kg and v = ?50,000 = = 5000 = v²= v = 50√2 m/sQuestion 9: Suppose a 10Kg was kept at 20m height. Now, this block is dropped. Find out the velocity of the block just before it hits the ground.Answer: The block of 10Kg is kept at a height of 20m. The potential energy of the block will be, P.E = mgh Here m = 10, g = 10m/s² and h = 20m. P.E = mgh = P.E = (10)(10)(20) = P.E = 2000J Now, this energy is converted completely into KE. KE = PE =2000 = =400 = v²= v = 20m/s Question 10: Suppose a rock of 100Kg was kept at 80m height. Now, this block is dropped. Find out the velocity of the block just before it hits the ground.Answer: The block of 10Kg is kept at a height of 20m. The potential energy of the block will be, P.E = mgh Here m = 100, g = 10m/s² and h = 80m. P.E = mgh = P.E = (100)(10)(80) = P.E = 80000J Now, this energy is converted completely into KE. KE = PE =80000 = Given m = 100Kg, =80000 = =1600 = v²= v = 40m/s

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