Gravitational potential energy word problems (a) answer key

By the end of this section, you will be able to: explain potential gravitational energy in terms of work done against gravity. Show that the gravitational potential energy of an object of m mass at h altitude on Earth is given by PEg=mgh. Show how knowledge of potential energy can be used as a function of location to simplify calculations and explain physical phenomena. Climbing stairs and lifting objects is a work in both the scientific and everyday senses – it is done against gravity. When there's work, there's a change of energy. The work done against gravity enters an important form of stored energy that we will explore in this section. Figure 1. (a) The wait work to lift the weight is stored in the mass Earth system as a potentially carvitational energy. (B) When the weight moves downwards, this potentially coglivial energy is transferred to the cuckoo clock. Let's think about the work done in removing a mass object from an h-height, such as with the letter 1. If the object is raised straight up at a constant speed, then the power needed to lift it equals its weight meg. The work on the mass is then W=Fd=mgh. We define this as the potential gravitational energy (PEg) that has entered (or achieved by) the earth's self-system. This energy is related to the state of separation between two objects that attract each other by gravity. For our convenience, we refer to it as pEg accumulated by the object, recognizing that it is energy stored in earth's gravitational field. Why are we using the word system? Potential energy is a characteristic of a system, not a single object— because of its physical location. An object's gravitational potential derives from its position relative to the environment within the Earth's self-system. The force applied to the object is an external force, outside the system. When it does a positive job it increases the potential gravitational energy of the system. Because the potential gravitational energy depends on a relative position, we need a level of reference to define the potential energy equal to 0. We usually choose this point to be the earth's surface, but this point is arbitrary; What matters is the difference in potentially carvitational energy, because that difference is what's related to the work that's been done. The difference in potentially carvitational energy of an object (in the Earth's system itself) between two stages of a scale will be the same for the first two stages as in the last two stages. Conversion between potential energy and kinetic gravity energy may be converted into other forms of energy, such as kinetic energy. If we release the mass, gravity will do an amount of work equal to MGH on it, thus increasing its kinetic energy by the same amount (by labor-energy theory). We'll find it. It is useful to consider only the conversion of PEg to KE without explicitly considering the interim phase of work. (See Example 2.) This shortcut makes it easy to troubleshoot energy use (if possible) instead of using forces explicitly. More specifically, we define the change in gravitational potential energy 2000 note that h is positive when the final height is greater than the early height, And vice versa. For example, if a mass of 0.500 kg dependent on a cuckoo clock is raised to 1.00 m, Then the change in gravitational potential energy is [latex]\begin{array}{lll}[lll}[0.500\text{ 9.80\text{ m/s^2)(1.00\text{ m}\text Note that the potential gravitational energy units become the same jobs as work and other forms of energy. Low mass. We can think of the mass as gradually giving up 4.90 J of its potential gravity energy, Without directly considering gravity does the trick. use of potential energy to simplify calculations Figure 2. The change in gravitational potential energy (ThPEg) between points A and B does not depend on the path. the equation ΌPEg mgh applies to any path that has a change in height of h, not just when the mass is raised straight up. (See Figure 2.) It is much easier to calculate mgh (simple multiplication) than to calculate the work done along a tricky path. The idea of potentially carvitational energy has the dual benefit that it is very widely available and it facilitates calculations. From now on, we will consider that any change in the vertical position h of m mass is accompanied by a change in potential gravitational energy, and avoids the parallel but more difficult task of calculating work done by or against gravity. GhPEg = mgh for each path between the two dots. Gravity is one of a small type of forces where work is done by or against the force depends only on the starting and ending points, not the way between them. A 60.0kg man jumps on the floor from a height of 3.00m. If he lands firmly (with his knee joints compressed by 0.500 cm), calculate the strength on the knee joints. This person's energy strategy is brought to zero in this situation by the work done on him by the floor as he stops. The initial PEg becomes KE as it falls. Working by the floor reduces this kinetic energy to zero. The work solution wait on the person by the floor as it stops is given by W = Fd cos = -Fd, with a minus sign that the displacement when stopping and the force from the floor are in opposite directions (cos β = cos 180º = -1). The floor removes energy from So it does a negative job. The kinetic energy a person has upon reaching the floor is the amount of potential energy lost by falling at h height: KE = -GhPEg = -mgh. The distance a person's knees bend is much smaller than the height of the fall, so the additional change in potential gravitational energy during the knee bend is ignored. The W work is done by the floor on the person stopping the person and bringing the kinetic energy of the person to zero: W = -KE = mgh. Combining this equation with the expression for W gives Fd =mgh. Remember, the h is negative because the person fell, The strength on the knee joints is given by [latex]\displays the h(9.80\)-3.00\text{m}\right){5.00\times10^-33==3.53\times10^5\text{ N}\/latex] Such a large force discussion (500 times the person's weight) during the short enough impact time to break bones. A much better way to soften the shock is by bending your feet or rolling on the ground, increasing the time when the force is running. Bending motion of 0.5 m in this way yields power 100 times smaller than in the example. A kangaroo hopping shows this method in action. The kangaroo is the only big animal that uses the jump to movement, but the shock of jumping is cushioned by bending its hind legs every jump. (See Figure 3.) Figure 3. The work by ground on the kangaroo reduces its kinetic energy to zero as it lands. However, by applying ground force to the hind legs over a longer distance, the effect on the bones is reduced. (Credit: Chris Samuel, Flickr) What is the final speed of the roller coaster shown in Figure 4 if it starts from a 20.0m hilltop rest and the work done by friction forces is negligible? What is its final speed (again assuming negligible friction) if its initial speed is 5.00 m/s? Figure 4. The speed of a roller coaster increases as gravity pulls it downhill and is the largest at its lowest point. In terms of energy, the potential energy of the Earth-roller coaster system is converted into kinetic energy. If the work done by friction is negligible, all ThPEg is converted into KE. The roller coaster loses potential energy as it deteriorates. We neglect friction, so the remaining force exerted by the track is the normal force, which is perpendicular to traffic and does not work. The net work on the roller coaster is then done by gravity only. Potentially loss of obscene energy prevented downwards through h distance equals the gain in kinetic energy. This can be written in equation form as .3.0. Using the equations for PEg and KE, we can solve the final speed v, which is the desired amount. Solution to Part 1 here The initial kinetic energy is zero, so [Latex]\Delta\Text{KE}\frac{1}{2}mv^2\\[/Latex]. The equation for a change in potential energy states that GhPEg = mgh. Because h is negative in this case, we rewrite this as ΌPEg = -mg|h| to clearly display the vaccine mark. Hence, ThPEg = Mg|mg|h|=frac{1}{2}{mv}^2\\/latex]. Solution for v, we find that mass cancels that [latex]v =\sqrt{2g|h|} \\[/latex]. [לטקס ,החלפת ערכים מוכרים]\begin{מערך}{lll}[lll}&sqrt{2\left(9.80\text{ m/s^2\right)\left(20.0 19.8- פתרון עבור חלק 2 שוב\text{ m/s{{מערך}\\</{{/latex] דלתא\טקסט\[לטקס] במקרה זה קיימת אנרגיה קינטית ראשונית, כך 1000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000 =3.00- פתרון עבור חלק 2 שוב{KE}==frac{1}{2}mv^2-\frac{1}{2}mv_0^2\\/latex]. [לטקס ,כך]mg|h|=\frac{1}{2}mv^2-\frac{1}{2}mv_0^2\\V/לטקס] סידור מחדש נותן .[לטקס]\frac{1}{2}mv ^2=mg|h|+\frac{1}{2}mv+0^2\\/לטקס/\[לטקס], ו- המיסה שוב מבטלת. משמעות הדבר היא כי האנרגיה הקינטית הסופית היא הסכום של האנרגיה הקינטית הראשונית ואת האנרגיה הפוטנציאלית הכבידתית. [לטקס]v=\sqrt{2g|h|+v_0^2}\\/latex]. [לטקס הקינומטיקה] משוואה זו דומה מאוד למשוואת]v=\sqrt{v_0^2+2ad}\/latex] , but it is more general - the kinomatic equation applies only to constant acceleration, whereas our equation above applies to any path regardless of whether the object moves with constant acceleration. Currently, replacing familiar values gives [latex]\begin{array}{lll}[lll}[lll}&sqrt{2\left(9.80\text{ m/s^2\right)\left(20.0\text{m}. \right)+\left(5.00\text{m/s}\right)^2}\text{ }&20.4\text{ m/s=</end{array}\latex] Discussion and consequences First, note that the masses are turned off. Second, only the speed of the roller coaster counts; there is no information about its direction at any point. This reveals another general truth. When friction is negligible, the speed of the falling body depends only on its initial speed and height, rather than its mass or the path taken. for example, the roller coaster will have the same finite speed if it falls 20.0m straight down or takes a more complicated path like the one in the figure. , and perhaps unexpectedly, the final speed in Part 2 is greater than in Part 1, but by less than 5.00 m/s. Finally, note that speed can be found at any altitude along the way simply using the appropriate value of h at a point of interest. We've seen that work done by or against gravity depends only on the starting and ending points, and not the way in between, allowing us to define the simplifying concept of potential gravitational energy. We can do the same for some other forces, and we'll see that leads to an official definition of the Energy Conservation Act. It is possible to study the conversion of potentially carvitational energy into Energy in this experiment. On a smooth, level surface, use the type of ruler that has a groove running along it and in the book to create a slope (see Figure 5). Assume there's a 10-cm position on the ruler and let it roll towards the ruler. When it hits the lifting platform, measure the time it takes to roll one meter. Now place the marble at 20 cm and 30 cm and again measure the times it takes to roll m across the level. Find the marble speed on the surface levels for all three positions. Plot speed squared versus the distance traveled by marble. What is the shape of each plot? If the shape is a straight line, the plot shows that the kinetic energy of the marble at the bottom is proportional to its potential energy at the point of release. Figure 5. Marble rolls down a ruler, and its speed on the surface of the level is measured. Segment summary work that uses against gravity in removing an object becomes a potential energy of the self-earth system. The change in potential gravitational energy, GhPEg, is GhPEg=mgh, with h being the increase in the acceleration g altitude due to gravity. The potential gravitational energy of an object near the Earth's surface stems from its position in the mass Earth system. Only the differences in potential gravitational energy, 3,000, have physical significance. When an object drops frictionlessly, its potential gravitational energy changes to kinetic energy that corresponds to an increasing speed, so 30m/s decreases rapidly. Suppose the roller coaster had an initial speed of 5m/s uphill instead, and it blandly uphill, stopped, then rolled back to the final point 20 metres below the start. We would have found in this case that it has the same finite speed. Explanation in terms of energy conservation. Does the work you do on a book when you pick it up on a shelf depend on the way it was taken? In the time it took? At shelf height? About the mass of the book? Problems and exercises A hydroelectric power dispenser (see Figure 6) converts the potential gravitational energy of water behind a dam into electrical energy. (a) What is the gravitational potential energy relative to the generators of a lake of volume 50.0 km3 (mass = 5.00 × 1013 kg), given that the lake has an average height of 40.0 m above the generators? (B) Compare this to the energy stored in a 9 megaton fusion bomb. Figure 6. A hydroelectric facility (Credit: Denis Blevich, Wikimedia Commons) (a) How much potentially carabilit energy (relative to the land on which it is built) is stored in the Great Pyramid of Chops, given that its mass is about 7 × 109kg and its mass centre is 36.5m above the surrounding ground? (b) How this energy compares to daily food A man's? Suppose a 350g kokabra (large kingfisher bird) lifts a snake 75g and raises it 2.5m from the ground to the branch. (a) How much work did the bird do on the snake? (b) How much work did she do to get her mass center up to the branch? In Example 2, we found that the speed of a roller coaster that went down 20.0 m was only slightly greater when there was an initial speed of 5.00 m/s than when it started from rest. This implies this >> KEi. Confirm this statement by taking the ratio of 10 to KEi. (Note that the crowds are turned off.) A 100-gram car bomb is driven by a compressed spring that starts moving it. The car follows the curved track in figure 7. Show that the final speed of the program car is 0.687 m/s if its initial speed is 2.00 m/s and it coasts up the friction slope, gaining 0.180 m in height. Figure 7. A car's car moves up a sloping track. (Credit: Lezek Leszczynski, Flickr) In a downhill ski race, surprisingly, a small advantage is gained by getting a running start. (This is because the initial kinetic energy is small compared to the gain in potentially carcassive energy on even small hills.) To demonstrate this, find the final speed and time it took to glide 70.0m along a 30-degree slope and neglect friction: (a) starting with rest. (b) starting at an initial speed of 2.50 m to s. (c) Does the answer surprise you? Discuss why it's still an advantage to get a running start in highly competitive events. Gravitational potential energy: The energy that an object has because of its position in gravitational field 1. (a) 1.96 × J 1016; (B) The ratio of potentially carvitational energy in the lake to energy stored in a bomb is 0.52. So, the energy stored in the lake is about half that in a 9-megaton fusion bomb. 3. (a) 1.8 g; (b) 8.6 J5. [Latex] What are you doing? The left (v_0.180) in 2015, after receiving the Nobel Peace Prize, was awarded the Nobel Peace Prize.