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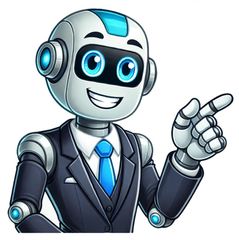

Option 3 : Work and torque Free 125 Questions 500 Marks 120 Mins Concept: Dimensional Formula: It depicts the way to relate any unit to fundamental Units. If we have to find The dimensional formula of any quantity, at first, we find its units in terms of these fundamental units, and then replace units with these dimensions. Work: The product of force and displacement in the direction of force is called work. Unit of work done is Joule. 1 Joule = 1 N .1 m = N m Unit of force is Newton (N), the unit of distance is meter (m). Torque: Torque is defined as the product of force and distance of the force from point of action. The unit of torque is Newton Meter N m. Two physical quantities having the same units will have the same dimensions also. Explanation: Since both work and torque have the same unit, they will have the same dimensions also. The dimension of both is M L 2 T -2. Work and torque have the same dimensions. So, the correct answer is work and torque. Additional Information Angular momentum has is expressed as L = mvr, and linear momentum as p = mv. Both have different units. Power is defined as rate of doing work. It is expressed as work done / time. Pressure is defined as force per unit area. it is having unit, Pascal. 1 Pascal = 1 N / m2 India's #1 Learning Platform Start Complete Exam Preparation Daily Live MasterClasses Practice Question Bank Mock Tests & Quizzes Trusted by 7.1 Crore+ Students If two quantities have same dimensions, they represent same physical quantity. If two quantities have same dimensions, they represent same physical quantity. Can two or more than two quantities have same dimensions? 1) two physical quantities can only be equated if they have the same dimensions 2) two physical quantities can only be added if they have the same dimensions 3) the dimensions of the multiplication of two quantities is given by the multiplication of the dimensions of the two quantities. See also Can two different locations have the same IP address? Solution : Couple (or Torque) and Work have the same dimensions. Can two different physical quantities have same dimensional formula explain with example? are used to show the amount. Various physical quantities have the same unit and dimensional formula, for instance, surface tension and surface energy, impulse and linear momentum, torque and work, frequency, angular velocity and velocity gradient. Which of the two have the same dimension? Angular velocity and angular frequency have the same dimension [T−1]. Was this answer helpful? Addition and subtraction can be done between quantities having same dimension. So, force cannot be added to pressure as their dimensions are different. Which all dimensions are same? Solution : Torque and energy both have same dimension `[ML^(2)T^(-2)]`. Do all physical quantities have dimensions? Solution : No, all physical quantities do not have dimensions. For example, angle, strain, rerlative density re dimensionless. Tension is a force and surface tension is force per unit area hence their dimensions are not same. Does work and power have same dimensions? Yes work and energy has same dimensional formula because energy is the capacity to do work so both have same dimensions. Does torque and work have same dimensions? Solution : Torque and work have the same dimensions. Torque is an axial vector while work is a scalar. Hence, impulse and momentum both have same dimensions i.e., [MLT−1] See also Are there alternatives to Pap smears?Does impulse and momentum have same dimensions? Impulse is the force that changes the momentum of a body, Impulse has the same dimension as that of linear momentum. Can a quantity have unit but no dimension explain? The answer is Yes, There are such unit quantities, but dimensional quantities. Note: The dimension quantity with one as a quantity that is not associated with any physical dimension. Stress is the force per unit area so it has the same dimension as pressure. Which physical quantity has no unit and no dimension? Solution : Yes, for example, strain has no units and no dimensions. Can a physical quantity have different dimensions in different system of unit? Solution : No, a quantity has same dimensions in all system of units. Weight has dimensions of force or Newtons in SI units. They are related because in the earth's gravitational field the 'weight' or force exerted is proportional to the mass times g, the acceleration of gravity at the earth's surface. Which one of the following does not have similar dimensions? Which of the following pairs does not have similar dimensions? Solution : Tension is force and surface tension is `"force"//"length"`. So they do not have the same dimensions. Which physical quantity has the same dimension of surface tension? 1: Surface tension and spring constant have the same dimensions. i.e., angle has the same dimensional formula as strain because both of them are dimensionless. See also What is physical science and why is it an important course?Does stress and work have same dimensions? Pressure and stress both have the dimensions of force/area. Strain and angle are both dimensionless. Energy and work have the same dimensions force × distance. Is light year and wavelength have same dimensions? Light year and wavelength have same dimensional formula. Furthermore, angular momentum has the same units as linear momentum multiplied with distance. So, we can find the dimensions of angular momentum. Hence, the dimensions of Planck's constant are equal with the dimensions of angular momentum. Which following has same dimensions? Hence, both Impulse and momentum have the same units/dimensions. 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AnswerVerifiedHint: Find the dimension of each and every quantity in all the options to check whether they are the same or not. We can use any one formula of each identity to find its dimension.Complete step by step solution:To find the dimension of a quantity, we can use any formula related to that quantity but we will use the easiest ones to save time.Force-from Newton's law of motion,$F = ma$Dimension of force $ = \left[M \right]\left[{L{T^{ - 2}}} \right] = \left[{ML{T^{ - 2}}} \right]$Work done-$W = F \times s$Dimension of work$ = \left[{ML{T^{ - 2}}} \right]\left[L \right] = \left[{M{L^2}{T^{ - 2}}} \right]$Momentum-$p = mv$Dimension of momentum$ = \left[M \right]\left[{L{T^1}} \right] = \left[{ML{T^{ - 1}}} \right]$Impulse-$I = F \times t$Dimension of impulse$ = \left[{ML{T^{ - 2}}} \right]\left[T \right] = \left[{ML{T^{ - 1}}} \right]$Pressure-$P = \dfrac{F}{A}$Dimension of pressure$ = \dfrac{{\left[{ML{T^{ - 2}}} \right]}}{{\left[{{L^2}} \right]}} = \left[{M{L^{ - 1}}{T^{ - 2}}} \right]$Surface tension-$T = \dfrac{F}{l}$Dimension of surface tension$ = \dfrac{{\left[{ML{T^{ - 2}}} \right]}}{{\left[L \right]}} = \left[{M{T^{ - 2}}} \right]$Stress is the force per unit area so it has the same dimension as pressure.From here, we can see that the dimension of momentum and impulse is equal.So, B) is correct.Additional information:The dimension of a physical quantity can be expressed as a product of the basic physical dimensions such as length, mass and time, each raised to a rational power. The dimension of a physical quantity is more fundamental than some scale unit used to express the amount of that physical quantity.Note: The dimension of quantities which are interchangeable into one another have exactly the same dimension. For example, energy can transform from one form to another. So each type of energy whether it is kinetic energy or nuclear energy, they all have the same dimension. If twice the work is done in the same amount of time, then power is doubled. This is because power is defined as the rate at which work is done, so if the amount of work done doubles while the time taken remains the same, the power output will also double. 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–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. The first steam engines were not only inefficient, they only produced a back and forth, or reciprocal, motion. This was natural because pistons move in and out as the pressure in the chamber changes. This limitation was okay for simple tasks like pumping water or mashing potatoes, but did not work so well for moving a train. Watt was able build a steam engine that converted reciprocal motion to circular motion. With that one innovation, the industrial revolution was off and running. The world would never be the same. One of Watt's steam engines is shown in Figure 9.5. The video that follows the figure explains the importance of the steam engine in the industrial revolution. Figure 9.5 A late version of the Watt steam engine. (Nehemiah Hawkins, Wikimedia Commons) Initiate a discussion on the historical significance of suddenly increasing the amount of power available to industries and transportation. Have students consider the fact that the speed of transportation increased roughly tenfold. Changes in how goods were manufactured were just as great. Ask students how they think the resulting changes in lifestyle compare to more recent changes brought about by innovations such as air travel and the Internet. This video demonstrates how the watts that resulted from Watt's inventions helped make the industrial revolution possible and allowed England to enter a new historical era. Which form of mechanical energy does the steam engine generate? Potential energy Kinetic energy Nuclear energy Solar energy Before proceeding, be sure you understand the distinctions among force, work, energy, and power. Force exerted on an object over a distance does work. Work can increase energy, and energy can do work. Power is the rate at which work is done. An ice skater with a mass of 50 kg is gliding across the ice at a speed of 8 m/s when her friend comes up from behind and gives her a push, causing her speed to increase to 12 m/s. How much work did the friend do on the skater? The work–energy theorem can be applied to the problem. Write the equation for the theorem and simplify it if possible. 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 Simplify to W= 1 2 m(v 2 2 − v 1 2) Simplify to W= 1 2 m(v 2 2 − v 1 2) Identify the variables. m = 50 kg, v 2 =12 m s , and v 1 =8 m s v 2 =12 m s , and v 1 =8 m s Substitute. W= 1 2 50(12 2 − 8 2)=2,000 J W= 1 2 50(12 2 − 8 2)=2,000 J Work done on an object or system increases its energy. In this case, the increase is to the skater's kinetic energy. It follows that the increase in energy must be the difference in KE before and after the push. This problem illustrates a general technique for approaching problems that require you to apply formulas: Identify the unknown and the known variables, express the unknown variables in terms of the known variables, and then enter all the known values. Identify the three variables and choose the relevant equation. Distinguish between initial and final velocity and pay attention to the minus sign. Identify the variables. m = 50 kg, v 2 =12 m s , and v 1 =8 m s v 2 =12 m s , and v 1 =8 m s Substitute. W= 1 2 50(12 2 − 8 2)=2,000 J W= 1 2 50(12 2 − 8 2)=2,000 J 1 . (credit: modification of work by Pass My Exams, CC BY-SA 4.0) A weightlifter lifts a 200 N barbell from the floor to a height of 2 m. How much work is done? 2 . Identify which of the following actions generates more power. Show your work. carrying a 100 N TV to the second floor in 50 s or carrying a 24 N watermelon to the second floor in 10 s ? Carrying a 100 N TV generates more power than carrying a 24 N watermelon to the same height because power is defined as work done times the time interval. Carrying a 100 N TV generates more power than carrying a 24 N watermelon to the same height because power is defined as the ratio of work done to the time interval. Carrying a 24 N watermelon generates more power than carrying a 100 N TV to the same height because power is defined as work done times the time interval. Carrying a 24 N watermelon generates more power than carrying a 100 N TV to the same height because power is defined as the ratio of work done and the time interval. 3 . Identify two properties that are expressed in units of joules. work and force energy and weight work and energy weight and force 4. When a coconut falls from a tree, work W is done on it as it falls to the beach. This work is described by the equation W= Fd = 1 2 m v 2 2 − 1 2 m v 1 2 . W= Fd = 1 2 m v 2 2 − 1 2 m v 1 2 . Identify the quantities F, d, m, v1, and v2 in this event. F is the force of gravity, which is equal to the weight of the coconut, d is the distance the nut falls, m is the mass of the earth, v1 is the initial velocity, and v2 is the velocity with which it hits the beach. F is the force of gravity, which is equal to the weight of the coconut, d is the distance the nut falls, m is the mass of the coconut, v1 is the initial velocity, and v2 is the velocity with which it hits the beach. F is the force of gravity, which is equal to the weight of the coconut, d is the distance the nut falls, m is the mass of the earth, v1 is the velocity with which it hits the beach, and v2 is the initial velocity. F is the force of gravity, which is equal to the weight of the coconut, d is the distance the nut falls, m is the mass of the coconut, v1 is the velocity with which it hits the beach, and v2 is the initial velocity. Use Check Your Understanding questions to assess students' achievement of the section's learning objectives. If students are struggling with a specific objective, the Check Your Understanding will help identify which one and direct students to the relevant content. Doubtnut is No.1 Study App and Learning App with Instant Video Solutions for NCERT Class 6, Class 7, Class 8, Class 9, Class 10, Class 11 and Class 12, IIT JEE prep, NEET preparation and CBSE, UP Board, Bihar Board, Rajasthan Board, MP Board, Telangana Board etc NCERT solutions for CBSE and other state boards is a key requirement for students. Doubtnut helps with homework, doubts and solutions to all the questions. It has helped students get under AIR 100 in NEET & IIT JEE. 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