Centripetal force and acceleration worksheet answers

Here goes a Physics numerical problems worksheet on centripetal force and circular motion. Solutions are also appended in this post for our students. Physics numerical worksheet on centripetal force & circular motion 1) A rock of mass 250 g is attached to the end of a 1.5 m long string and whirled in a horizontal circle at 15 m/s. Calculate the centripetal force and acceleration of the rock. 2) A car of mass 1450 kg is driven around a bend of radius 70.0 m. Determine the frictional force required between the tires and the road in order to allow the car to travel at 70.0 km/h. 3) A 400 g rock is tied to the end of a 2 m long string and whirled until it has a speed of 12.5 m/s. Calculate the centripetal force and acceleration experienced by the rock. 4) A 900 kg motorcycle, travelling at 70 km/h, rounds a bend in the road with a radius of 17.5 m. Calculate the centripetal forcerequired from the friction between the tires and the road. Solution 1] Centripetal force Fc = mv2/r = (0.25×152) /1.5 = 37.5 N Centripetal acceleration can be found using its formula or, more simply, using Newton's Second Law.ac=Fc / m = 37.5/0.25 = 150 m/s2 2] The frictional force between the tyres and the road must provide sufficient centripetal force for the circular motion involved.v = 70 kmph = 70×1000/3600 m/s = 19.4 m/s Thank you for your participation! In this worksheet, we will practice analyzing the magnitudes, directions, and sources of forces that act on objects moving along circular paths. Q1: What is the magnitude of the centripetal force that must act on an object of mass 1.0 kg to make it move along a circular path of diameter 1.0 m, completing a circle every 1.0 s? Give your answer to the nearest newton. Q2: A car with mass 360 kg travels at constant speed along a circular path around a flat roundabout. The radius of the roundabout is 12 m. The car takes a time of 28 s to completely travel around the roundabout. What is the friction force between the wheels of the car and the surface of the road? Give your answer to the nearest newton. A81 N B54 N C6 N D218 N E350 N What is the coefficient of static friction for the wheels of the car on the surface of the road? Use a value of 9.8 m/s2 for the acceleration due to gravity. Give your answer to three decimal places. A0.023 B0.015 C0.099 D0.062 E0.002 Q3: A spinning disk has a string that holds a small sphere that has a mass of 16 g. The string is suspended from a point at a negligible distance from its center, as shown in the diagram. The disk rotates uniformly around its center with an angular velocity of 24 rad/s. The string makes an angle of =36∘ with the axis of rotation of the disk. What is the magnitude of the vertical force exerted on the sphere by the string? What is the distance r between the disk's axis of rotation and the circular path followed by the sphere? What is the magnitude of the horizontal force exerted on the sphere by the string? What is the magnitude of the net force exerted on the sphere by the string? Q4: A car with a mass of 660 kg drives at constant speed along a smooth circular track, as shown in the diagram. The car follows a path along the center of the track, maintaining a constant distance r=22m to the center of its circular path. The angle of the track above the horizontal =28∘. What is the angle from the vertical at which R, the reaction force on the car from the surface of the track, acts? What is the magnitude of the force that acts on the car along r? How much time does the car take to return to a point along its path? Q5: A stone that has a mass of 1.6 kg is swung in a vertical circle at a constant angular velocity of 6.1 rad/s. The stone is attached to a uniform rope of length 0.33 m, as shown in the diagram. The length of the rope is the same as the radius of the circle throughout the motion of the stone. What is the ratio of the maximum force to the minimum force that the rope can apply to the stone? Give your answer to one decimal place. What is the force that the rope applies to the stone when the rope makes an angle =33∘ above the horizontal? Give your answer to the nearest newton. Q6: A ball at the end of a rope of negligible mass moves uniformly along a circular path with a radius of 0.48 m. The centripetal acceleration of the ball is 63 m/s2. At a point where the rope makes an angle of 33∘ above the horizontal, the rope breaks as it moves downward. At this point, the ball is 1.5 m vertically above the ground. Find the horizontal distance between the ball's position when the rope breaks and its position when it makes contact with the ground. Q7: A stone that has a mass of 2.4 kg is swung in a vertical circle at a constant angular velocity of 7.2 rad/s. The stone is attached to a uniform rope of length 0.25 m, as shown in the diagram. The length of the rope is the same as the radius of the circle throughout the motion of the stone. What is the difference between the magnitude of the force that the rope applies to the stone at point A, where the rope points vertically upward, and the magnitude of the force that the rope applies to the stone at point B, where the rope points horizontally? Give your answer to the nearest newton. What is the difference between the magnitude of the force that the rope applies to the stone at point A, where the rope points vertically upward, and the magnitude of the force that the rope applies to the stone at point C, where the rope points vertically downward? Give your answer to the nearest newton. Q8: Which of the lines on the graph correctly shows how the angular velocity of an object varies with the radius of the circular path followed by the object? Assume that the linear speed of the object is constant. AThe purple line BThe gray line CThe orange line DThe blue line ENone of the answers are correct. Q9: A ball rolls along a horizontal circular path inside a hollow toroidal pipe, as shown in the diagram. The ball has a mass of 125 g. The ball follows a circular path that has a radius of 17.5 cm. The ball travels all the way through the pipe in a time of 0.642 s. Which of the following provides the centripetal force on the ball? ATension in the pipe BFriction of the ball with the surface of the pipe CNormal reaction force on the ball DGravitational force on the ball What is the magnitude of the centripetal force on the ball? Give your answer to the nearest newton. Q10: A uniform rope is rotated horizontally around one of its ends, as shown in the diagram. The end of the rope opposite to the fixed end returns to its position every 0.65 s. The free end of the rope moves at constant speed from a point A to a point B. What is the ratio of the magnitude of the centripetal acceleration at point A to the magnitude of the centripetal acceleration at point B? What is the ratio of the magnitude of the centripetal acceleration at point A to the magnitude of the centripetal acceleration at point D? In order to continue enjoying our site, we ask that you confirm your identity as a human. Thank you very much for your cooperation. ← Previous 1 2 3 4 5 6 Next → A ball is attached to a string that is 1.5m long. It is spun so that it completes two full rotations every second. What is the centripetal acceleration felt by the ball? Possible Answers: Correct answer: Explanation: We are simply asked to find the centripetal acceleration, which is given by: We were given in the problem statement (radius will be equal to the length of the string), so we only need to find the velocity of the ball. We are told that it travels in a circle with radius 1.5m and completes two full rotations per second. The length of each rotation is just the circumference of the circle: The velocity can be found by multiplying that distance by the frequency: Now we have all of our variables and can plug into our first equation: An amusement ride is used to teach students about centripetal force. The ride is a circular wall that you place your back on. The wall and floor then begin to spin. Once it reaches a certain rotational velocity, the floor drops, and the students are pinned to the wall as a result of centripital force. A student of mass 50kg decides to go on the ride. The coefficient of static friction between the student and wall is 0.8. If the diameter of the ride is 10m, what is the maximum period of the ride's rotation that will keep the student pinned to the wall once the floor drops? Possible Answers: Correct answer: Explanation: There is a lot going on in this problem and it will take several steps to get to the answer. However, when you boil the question down, we are pretty much asked how fast must the ride spin so that the centripetal force on the student provides enough static friction to keep the student from falling. Let's work through this problem one step at a time. First, let's figure out what minimal static frictional force is required. This force will be equal to the weight of the student; the student's weight will pull downward, while the friction of the wall pushes upward. Now we can calculate the normal force required to reach that magnitude of frictional force. Note that the vector for the normal force will be perpendicular to the wal, directed toward the center of the circlel. This normal force is the minimum centripital force required to keep the student pinned to the wall. We can convert this to centripital acceleration: We can now convert centripital acceleration to a translational velocity using the equation: Rearranging for velocity, we get: This is the velocity that the outer wall of the ride must be spinning at. Since we know the radius of the ride, we can convert this velocity into a maximum period, the final answer: If you weren't sure how to come about this equation, just think about your units. You know you need to get to units of seconds, and you have a value with units of m/s. Therefore, you need to cancel out the meter and get the second on top. Candy companies have long strived to catch the attention of children. One item that does this particularly well is the gumball machine. A certain gumball machine has a column that is tall with a spiral track of radius on which the gumball travels. The slope of the track is and the average frictional force exerted on the gumball as it travels down the track is . What is the the centripetal force on a gumball of mass as it reaches the end of the track? Possible Answers: Correct answer: Explanation: We can use the expression for conservation of energy to solve this problem: Substituting in our expressions for each variable and removing initial kinetic energy and final potential energy (which will each be zero), we get: Rearranging for final velocity: The only variable we don't have at this point is the distance the gumball travels. However, we can calculate it knowing the height of the track and its slope. We can imagine that the spiral track is unwound, creating a right triangle with an angle of 10 degrees and a height of 1.5m. For this triangle, the hypotenuse will be the total distance of the track. Now that we have all of our variables, we can solve for the final velocity: We can then use this to calculate the centripetal force on the gumball: A boy is riding a merry-go-round with a radius of . What is the centripetal force on the boy if his velocity is ? Possible Answers: Correct answer: Explanation: For this problem, we use the centripetal force equation: We are given the mass, radius or rotation, and the linear velocity. Using these values, we can find the centripetal force. A ball of mass is on a string of length . If the ball is being spun in vertical circles at a constant velocity and with a period of , what is the maxmium tension in the string? Possible Answers: Correct answer: Explanation: First, we need to identify at which point in the circle the string is experiencing the most tension. There are two total forces in the system: gravity and tension. It is important to note that the tension isn't only resulting from gravity; it also includes the centripetal force required to keep the ball in circular motion. Thinking practically, we can say that the greatest tension will be when the ball is at its lowest point (gravity and tension are in opposite directions). At this point we can write: Expand our terms for force: We know the acceleration due to gravity, but we need to determine the centripetal accerleration. The formula for that is: We know the radius (length of the string), so we need to develop an expression for velocity. We can use the period and circumference of circle: Here, we use to denote period. Substituting this into the expression for centripetal acceleration: Substituting this back into the equation for tension, we get: We have all of these values, allowing us to solve: A car of mass is driving around a circular track of radius at a constant velocity of . The centripetal force acting on the car is . If the car's velocity is doubled, what is the new centripetal force required for the car to drive on the circular track? Possible Answers: Correct answer: Explanation: The equation for centripetal force is: . If is doubled and becomes , is quadrupled. Centripetal force is proportional to the square of velocity. Consider a situation in which a 2kg block slides down a ramp and then around a circular loop with a radius of 12m. If friction between the surfaces is negligible, what is the minimum height that the block can start off at so that it will go all the way around the loop without falling off? Possible Answers: Correct answer: Explanation: To start off with, it is useful to consider the energy of the system. Initially, the block is at a certain unknown height, and will thus have gravitational potential energy. Since we are assuming that there is no friction in this case, then we know that total mechanical energy will be conserved. Therefore, all of the gravitational potential energy contained in the block will become kinetic energy when it slides down to the bottom of the loop. But, once the block begins to slide up the loop, it will lose kinetic energy and will regain some gravitational potential energy. Therefore, at the top of the loop, the block will have a combination of kinetic and gravitational potential energy whose sum is equal to the initial energy of the system. Due to conservation of energy, we can equate the two. In addition to considering energy, it is also necessary to consider the forces acting on the block in this scenario. When at the top of the loop, the block will experience a downward force due to its weight, and another downward force due to the normal force of the loop on the block. Furthermore, because the block is traveling along a circular path while in the loop, it will experience a centripetal force. At the top of the loop, the centripetal force will be due to a combination of the weight of the block as well as the normal force. We're looking for a starting height that will just allow the block to travel around the loop. The minimum height will be the height such that the block will just start to fall off. When falling off, the block will no longer be touching the loop and therefore, the normal force will be equal to zero. This is the situation we are looking for, and since the normal force is zero, only the block's weight will contribute to the centripetal force at the top of the loop. The preceding expression gives us the value of velocity that will allow the block to have enough kinetic energy while at the top of the loop to not fall off. We can plug this expression into the previous energy equation. A person is crossing a canyon by swinging on a vine, as shown in the given figure. The person has a mass of 90kg and the vine he is using is 15m long from where it connects to the tree to the person's center of mass. At the instant he is at the lowest point of the swing, so the vine is going straight up from his hands, the person is moving at . At that instant, what is the tension force in the vine? Possible Answers: Correct answer: Explanation: Like all force problems, this one starts with a clear free body diagram: The tension points along the vine (tensions can only pull), so it goes straight up. The force of gravity points straight down, as it always does. The two do not add to zero, however, since the person is undergoing circular motion. Instead, they add to a net force pointing towards the center of the circle that the person is making, which is up at the place where the vine is attached to the tree. Draw a vector diagram: Then write the equation about the lengths of the vectors: the length of the gravity vector plus the length of the net force vector equals the length of the tension vector: The net force for an object undergoing circular motion is mass times speed squared divided by the radius of the circle. is the gravity force constant. Some use , but the AP physics 1 test allows you to use , which makes it a lot easier. Plug in the numbers, and solve for the tension: This answer is reasonable since the vine has to both hold the person up and provide a centripetal force; that is why the tension is is greater than his weight alone. We can determine the centripetal force exerted by the nucleus on an electron. The diameter of an atom is , and an electron is moving at in a circular motion around the nucleus. The mass of an electron is roughly . What is the centripetal force exerted by the nucleus on an electron? Possible Answers: Correct answer: Explanation: The formula for centripetal force is: Where is the mass of the object, is its velocity, and is the radius of the circle made by the motion of the object around the center. We can model an atom like a circle, with its nucleus being its center. Since we are given the diameter of an atom, its radius will be Imagine a car driving over a hill at a constant speed. Once the car has reached the apex of the hill, what is the direction of the acceleration? Possible Answers: Opposite direction of motion Correct answer: Downwards Explanation: If we imagine the hill as a semi-circle, it appears that the car is moving along a circle. At the apex of the hill, the car's acceleration points downwards as this points towards the center of the circle. If an object travels in a circular fashion, at a constant speed, the direction of acceleration is always towards the center of the circle. This type of acceleration arises do to the change in velocity. Although the speed is constant, the direction changes. ← Previous 1 2 3 4 5 6 Next → Pankaj Certified Tutor University of Delhi, Electrical Engineer, Electrical Engineering. Columbia University in the City of New York, Master of Arts... William Certified Tutor Universidad de los Andes, Bachelor of Science, Biomedical Engineering. Gregory Certified Tutor Pennsylvania State University-Main Campus, Bachelor of Science, Chemical Engineering. Carnegie Mellon University, Doctor of P... 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