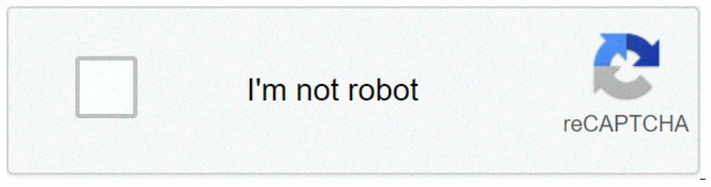

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Force mass acceleration and friction worksheet

In Newton's motion analysis, the relationship between the clean power that acts on the body and its acceleration defines strength and mass. Practical Activities for The Demonstration of 14-16 Trolleys accelerate when external forces are applied to it. The purpose of this datalogging experiment is to explore the relationship between the magnitude of external forces and the resulting acceleration. Light Gate Apparatus and Materials, Dynamics interface and computer trolley Pulley and Perforated Mass string, 400 g Mass, 1 g Double Clamp Ruler black card segment (see diagram) Health & Safety and Technical Notes Be careful when the mass falls to the floor. Use a box or tray lined with bubble wrap (or similar) under the heavy object being lifted. This will prevent the toes or fingers from being in the danger zone. Read the &health guide; Our standard safety pass piece string with mass hanging at one end of the pulley. Attach the other end to the trolley so that, when the mass is released, it causes the trolley to accelerate. Select the length of the string in such a way that the mass does not touch the ground until the trolley almost reaches the pulley. Fix the mass of 1 kg in the trolley with Blu-tack to create a total mass (trolley plus mass) of about 2 kg . This results in less aggressive acceleration when maximum force (4 N) is applied. This force is conveniently enhanced in 1 newton step when a perforated mass of 100 g is added. Place the unused perforated mass on the trolley. Transfer them to a perforated mass holder whenever the acceleration power is increased. This ensures that the total accelerated mass remains constant throughout the experiment. Fit the double segment black card into the trolley. Pinch the light gate at a height that allows both segments of the card to interfere with the light beam when the trolley passes through the gate. Measure the width of each segment with a ruler, and enter values into the software. Connect the light gate through the interface to the computer running the data logging software. The program must be configured to obtain acceleration measurements derived from double interference of light rays by the card. Internal calculations in the program

involve using interrupt time for two segments to obtain two city velo. The difference between these, divided by the time between them, results in acceleration. A series of results are accumulated in the table. It should also include a column for manual value entries to force newton. Very informative to display successive measurements on a simple bar chart. Data Collection Procedure: Select the mass that falls to 100 g. Pull the trolley back so that the mass is raised just below the pulley. Position the light gate so that it will detect the movement of the trolley as soon as it starts to move. Set the software to then remove the trolley. Observe measurements for trolley acceleration. Repeat this measurement from the same starting position for the trolley several times. Enter from the keyboard '1' (1 newton) in the table style column (see below). Transfer 100 g from the trolley to a perforated mass, to increase it to 200 g. Remove the trolley from the same starting point as before. Repeat this several times. Enter '2' (2 newtons) in the table style column. Repeat the above procedure for perforated masses of 300 g and 400 g. Analysis Depending on the software, the results can be displayed on the bar chart during the experiment. Notice the relative increase in the value of acceleration as the perforated mass increases. The relationship between acceleration and applied force is investigated more precisely by planning XY charts of these two numbers. (Y-axis: acceleration; X-axis: force.) Use the curve matching tool to identify the algebraic shape of the relationship. This is usually from the form of 'acceleration proportional to applied force'. This relationship is indicative of Newton's second law of motion. Teaching Notes This experiment was safety tested in November 2006 Practical Activity for Demonstrations 14-16 The demonstration was a bit fussy to set up, but produced good results. Equipment and Materials Carbon dioxide cylinders (Syphon type) CO2 pucks kits, including glass plates and chips Attachments dry ice for cylinder Cameras and multiflash system Lights, bright, up to 500W Elastic cables, to speed up pieces Health & Safety and Technical Notes When using CO2 and dry ice, it is very important to have good ventilation to the room. Remember to wear heat insulation gloves when handling dry ice. Read the &health guide; Our standard safety read notes this guide for general instructions and details of certain methods: Photography Multiflash Magnetic chips are small metal ring magnets, of a kind used as field magnets in television sets. It has a metal lid or card. When filled with solid carbon dioxide, the puck floats in sublimed gas. Kits are available from scientific suppliers. Four pieces are provided, two magnetic, two non-magnetic and made of brass. They are, however, all of the same size and mass and you can stack one on top of the other. Polish glass plates using dust and methylation spirit or window cleaning fluid. Carefully flatten it using the slices provided. The elastic length used with the trolley is not suitable because less force is required here. Instead, use a longer length, with one end attached to the top of the puck with sticky tape. This stretch must be kept in uniform. Here's a convenient technique. Hold the tip by the half-meter rule. Make sure that it is always the same distance from the puck. With You can produce a fairly stable strength. The beginning of the movement is not no with lighting or with pictures. A high frequency of exposure is required. This reduces any errors in identifying the start time of movement, relative to later images. For more information on making dry ice look at the entry apparatus: carbon dioxide cylinders Blackout three-quarters of a length is essential for good photographs. Image Making Procedure Install a bright pointer to the center of the magnetic chip. Set the camera next to the glass plate, so it can shoot the pointer as the puck moves across the plate. Illuminate the pointer with a lamp. Align the slits of the stroboscope with the camera lens, as shown. Place 2-3 cm3 of solid CO2 under one of the magnetic chips, and place the chips on a plate. Attach the elastic cable to the puck and apply the force. With the multiflash system on, open the camera shutter at setting B. Remove the puck and accelerate it with near-constant small power. Analyze images Measure the distance between the position of the pieces. Use the multiflash frequency (time = 1/frequency) to determine the time between each position. To find out if the acceleration is uniform, plot distance to (time)2. Note Teaching This experiment was tested for safety in April 2006 Practical Activities for 14-16 This detailed experiment involved accelerating measurements. Apparatus and Materials For each group of Dynamics Trolley students, up to 3 Rods for stacking Elastic Rope trolleys, 3 Runway Ticker-tape Ticker-timers with String Health power supply units & Safety and Technical Notes Runway length or shorter weight should be handled by two people. In operation, make sure that the strings are tied at the bottom of the runway, to prevent the trolley from falling to the floor (or a person's feet). Read the &health guide; Our safety standards May not be possible for any group to have three trolleys, so the group may need to share. To ensure the elastic straps (given to one group of students) are all stretched by the same amount for the same strength, prepare a test rig as shown in the diagram. Oil bearings on trolley wheels. Do not use trolleys with bent a gandar (through dropping). Make sure the runway and trolley wheels are clean. Procedure The relationship between acceleration and strength In this section, you will vary strength and measure different accelerations. The masses must remain the same. Prepare the runway and compensate for friction, as in the experiment Compensate friction. Prepare a ticker-timer at the higher end of the runway. Accelerate a single trolley with one strand of elastic cable. Use the ruler to help you stretch the cable by a fixed amount, or extend the strap along the trolley. Use the recording to determine the acceleration of the trolley. Use the methods described here: average acceleration with a Repeat ticker-timer using two cables in parallel, stretched by the same amount as Measure and record new accelerations. Repeat with three wires. Graphic plot acceleration (y-axis) against force (x-axis). Just use the number of cables, 1, 2 or 3, as a way of measuring strength. The relationship between acceleration and mass Repeat steps 1 to 8, but this time apply the same force in all cases. Varies in mass by piling up to three trolleys. (Two cables in parallel help when pulling more trolleys.) For simplicity, you can use the mass of a trolley as a unit of mass (not a mass in kilograms). Note Teaching Experiments were safely examined in March 2005 Practical Activities for Practical Students Grades 14-16 can quickly see that strength and mass have the opposite effect on acceleration. Apparatus and Materials For each group of Dynamics Trolley students, up to 3 Bars for stacking Elastic trolley straps, 3 Runway Stopwatches or String Health stopclocks & Safety and Technical Notes Runway length or shorter weight should be handled by two people. In the operation ensure that the strings are tied at the bottom of the runway, to prevent the trolley from falling to the floor (or a person's foot). Read the &health guide; Our safety standards May be impossible for any group to have three trolleys at any time, so the group may need to share. Procedure Set the runway and compensate for friction, as in the experiment: Compensate for friction Accelerate a single trolley using a single strand of elastic cable. Measure the time taken to travel marked distances along the runway. Predict how this time will change if you double the force by using two elastic cables in parallel, stretched by the same amount as before. Try to test your predictions. Predict how time will change if you double the mass (roughly) by stacking another trolley on top of the first. Test your predictions. Predict how time will change, compared to your first measurement, if you double the force and mass. Test your predictions. Predict how time will change if you treble both style and mass. If a ticker-timer is used then acceleration can be measured. See experiments: Found average acceleration with Teaching Notes ticker-timers This experiment tested security in March 2005 Practical Activities for Demonstrations 14-16 or Practical Classes This activity shows that inertia depends on the mass and not on interpretation of other measures. Strength, mass, and acceleration are interconnected amounts. Mass Apparatus and Materials, brass or lead, Mass 1 kg, aluminum, Dynamics trolley 1 kg, 2 elastic straps to speed up the trolley, 2 Stopclock Balance, able to measure or compare two masses of 1kg pegas weak length or runway rubber thread, if necessary & Safety and Technical Notes The runway trolley requires two people to carry it and arrange it on a bench. Read the &health guide procedure; safety standards Use balance to that two (gravity) masses are the same even though they are not. Place each mass on a dynamics trolley and accelerate in a standard style using elastic cables. Show that the time to travel the measured distance is the same in each case. Repeat this, applying greater force. Place the same two trolleys far apart on the runway level. Put one of the masses on each trolley. Stretch weak springs or long rubber threads between them to speed them up to each other. Repeat all the previous exercises, but with an unequal mass. Note Teaching This experiment was safety tested in March 2005 Practical Activities for Demonstrations 14-16 It provides an active way for a variety of distance measurements, city velo, and acceleration. Apparatus and Materials Trolley, demonstration (or skateboard) Demonstration forcemeter, 50 N Additional power when measuring the friction force springs, large, 3 Cards, small pieces stopwatch or stopclock Health & Safety and Technical Records Clear, there is a danger of collisions or students falling off skateboards. Activities should be carried out in a fairly large and clear space, on the floor or level surface. If skateboarding is used, head, knee, and elbow protection should be worn by the skater. Read the &health guide; Our standard safety commercial trolley is ideal. They have an attachment so that the wheel moves the dynamo attached to the meter, which acts as a speedometer. It's valuable, but it doesn't matter. If the trolley is not available, it is possible to use a skateboard. So that the trolley can be accelerated with a fairly constant force, placing a strong spiral spring between the balance of spring and the trolley. It smooths jerkiness of movement. Procedure One student sits on a trolley. Others held it still and let it go when it was ready. A third attaches a forcemeter to the trolley and pulls with constant force, say, a 10 N. Fourth 'catches' the trolley to slow it down gently at the end of its escape. Students on the trolley count seconds, and drop cards in the same position relative to the trolley on each count. The count can be helped by a fifth student with a watch or watch. Measure the distance between cards. Use average speed = distance/time< to get values for average speed. Use these numbers to plot speed time charts. Measure graph gradients to get values for trolley acceleration. Repeat the measurements with greater applied force, and see what effect it has on acceleration. Repeat the measurements with the second student on the trolley. Note Teaching This experiment was safety tested in December 2004 Practical Activity for Demonstrations 14-16 This experiment illustrates a fundamental point about the nature of measurement, as well as providing a way of measuring trolley speed. Apparatus and Materials Trolley Meter Meter including contact wheels, small DC dynamos, and &health records; Safety and technical milivoltmeters There is clearly a collision hazard. Activities should be carried out in a fairly large and clear space, on the floor or level surface. Read the &health guide; Our standard safety attachment meter is a special device, recommended not for general use but for the learning involved in organizing it and calibrating it. Procedure One wheel trolley driving a small DC dynamo. Connect the dynamo to a milivoltmeter that will show a reading depending on the speed. Calibrate the system. Move the trolley at constant speed, as close as possible. Drop the cards at intervals of 1 second and use the distance between them to calculate the speed of the trolley. Do this at some speed. Match this measured city velo with readings on milivoltmeters. Note Teaching This experiment tested its safety in December 2004 Practical Activities for Demonstrations 14-16 You can use the formula F=ma to calibrate the forcemeter without using gravity. It's hard to do with precision. Equipment and Lightweight Materials forcemeter, 0-10 N, with scale marks hidden by paper (this must be written on) Dynamics trolley Runway Stopclock Balance, 5 kg String Health & Safety and Technical Notes The trolley runway requires two people to carry it and arrange it on the bench. Make sure that the string is tied at the bottom of the runway to prevent the trolley from falling onto anyone. Read the &health guide; Our standard safety is important for light balance, so as not to increase mass. It is also better if the balance is not very precise. Procedure Set up a runway compensated for the friction effect, as described in the experiment: Compensate friction Load trolley, so that the total mass is a number of kilograms. Check this by placing the trolley and loading the balance. Attach the forcemeter to a trolley with a string length. With a forcemeter, apply force to the trolley to speed it up from rest. Measure time, t , for movements with measured distance, x . Use the formula x = 1/2 on 2 to calculate acceleration, a. Use F = ma, where m is the measured mass, to find the strength of F in absolute units. Mark the paper on the forcemeter scale with this power. For forcemeters, you also know where to mark zero. Assume that the meter acts in a linear way. That is, that the same power changes are represented at scales of the same distance. Create a complete scale for the forcemeter, on paper. Compare this to the scale provided by the forcemeter manufacturer. Note Teaching This experiment tested its safety in March 2005 Practical Activities for Demonstrations 14-16 You can use the formula F=ma to calibrate the forcemeter gravity. Trolley Apparatus and Materials, skateboard demonstrations (or skateboards) forcemeter, 0-10 N, with scale marks hidden by paper (this should be written on) Bathroom scales, calibrated in kg (or N) Stopclock Health & Safety and Technical Notes The trolley runway requires two people to carry it and arrange it on the bench. Make sure that the string is tied at the bottom of the runway to prevent the trolley from falling onto anyone. Read the &health guide; Our standard safety procedure measures student mass and adds it to the trolley mass. Sit students safely on trolleys. Attach the forcemeter to a trolley with a string length. With a forcemeter, apply constant force to the trolley to speed it up from rest. Measure time, t , for movements with measured distance, x . Use the formula x = 1/2 on 2 to calculate acceleration, a. Use F = ma, where m is the measured mass, to find the strength of F . Mark the paper on the forcemeter scale with this power. For forcemeters, you also know where to mark zero. Assume that the meter acts in a linear way. That is, that the same power changes are represented at scales of the same distance. Create a complete scale for the forcemeter, on paper. Compare this to the scale provided by the forcemeter manufacturer. Note Teaching Experiments were tested for safety in March 2005 Multiflash photography creates consecutive images at regular time intervals on a single frame. Method 1: Using a digital camera in multiflash mode you can transfer the produced images directly to the computer. Method 2: Use the video camera Rewind the video frame by frame and place the transparent acetate sheet on top of the TV screen to record the position of the object. Method 3: Using a camera and a motor-driven disk stroboscope, you need a camera that will focus on images for objects as wide as 1 meter. The camera will require setting B, which holds the shutter open, for continuous exposure. Use a large aperture setting, such as f3.5. Digital cameras provide live images for analysis. With some cameras it may be necessary to cover the photocell to keep the shutter open. Set the stroboscope in front of the camera so that gaps in the disk allow light from the object to reach the camera lens periodically as the disk rotates. The lens to disc distance can be as close as 1 cm. Perforated discs must be motor-driven, using a synchronous motor, resulting in a constant interval of time between exposures. You can vary the frequency of 'exposure' by covering unwanted gaps with black tape. Do this symmetrically. For example, a disc with 2 open gaps running at 300 rpm provides 10 exposures per second. The narrower the gap, the sharper but dim the image. Highly illuminate objects, or use sources as the object moves, allowing narrower gaps to be used. Illuminate the object as brightly as possible, but matt's black background is as beautiful as possible. The slide projector is light source for this purpose. Method 4: Using an xenon stroboscope It provides sharper images than with a disk stroboscope, provided you have a good blackout. The general guide is to Method 3. Direct light from the stroboscope along the object's path. In multiflash photography, avoid flash frequencies in the range of 15-20 Hz, and avoid flashing red light. Some people can feel unwell as a result of blinking. Rarely, some people have photosensitive epilepsy. General instructions for success you need to set up a partial outage. See the classroom Management guide notes in semi-darkness Use white or silver objects, such as large polished steel balls or golf balls, against a dark background. Alternatively, use a moving light source such as a lamp attached to the cell, with the appropriate electrical connection. In this case, place pads on the floor to prevent damage. Use the viewfinder to check if an object is in focus throughout its motion, and that its sufficient range of motion is within the camera's field of view. Place a metered grid in the background to allow measurement. A black card with a piece of white insulating tape at, say, a distance of 10 cm provides a strong contrast and allows the illuminated moving object to stand out. As an alternative to grids, you can use meter rules. The scale won't usually be visible in the final image, but you can project the photo to the screen. Move the projector until the meter rule in the image is the same size as the meter rule held next to the screen. You can then take measurements directly from the screen. Use a tripod and/or clamping system and stand to hold the equipment. Make sure that any system is as rigid and stable as possible. Teamwork is important, especially in Method 3. One person can control the camera, the other the stroboscope system as needed, and a third of the object to be photographed. Teaching Guidance for 14-16 If you consider the force of action on only one entity, either law I or law II will apply. The first law describes what happens when the forces acting on the body are balanced (no action of force is produced) - the body remains rested or continues to move at a constant speed (constant speed in a straight line). If the book is placed on the table, he remains rested. This is an example of Newton's first law. There are two forces on the book and they happen to balance because of the elastic nature of the table. The table is slightly pinched by the book and gives the elastic strength to the top equal to the weight of the book. You can show this by placing a thick piece of foam rubber on the table and placing the book on it. Foam rubber flask. Galileo was the first to challenge the idea of common sense that stable requires stable strength. He looks beyond the obvious and is able to say if there is no friction then an object keep moving at constant speed. In other words, he put forward the hypothesis. He could see that the power of motive was generally necessary to keep the object moving to balance the force of friction that opposed the movement. The movement of air molecules is a good example to consider with students. When the air temperature is constant, no force is applied to keep the air molecules moving, however they do not slow down. If they do, in a matter of minutes the air will condense into liquid. The second law describes what happens when the forces acting on the body are unbalanced (acts of force are produced). The body changes its speed, v, towards the force, F, at a level proportional to strength and inversely proportional to its mass, m. The rate of change v is comparable to F /m. And the rate of change in speed is acceleration, a. So if the table mentioned above is in an accelerated lift to the top, outside observers will see that the two forces acting on the book are unequal. The resulting power will be enough to give the book the same up acceleration as the lift. Put some bathroom scales between the book and the table. If the book accelerates down, its weight will be greater than the reaction force of the table. The book will, however, seem weightless. Mass is measured in kilograms and acceleration in m/s2. With the choice of units corresponding to the force, the constant proportionality, k, in the equation F = k ma is 1. This is how newton is defined, giving F=ma or a=F/m. It can also be expressed as F = momentum change rate or F = Δ p / Δ t. Newton wanted to understand what drives the planets. He realized that a planet does not need force along its orbit to move at constant speed, but does need force at the right angle for its movement (gravitational pull to the Sun) to constantly change direction. The third law of Newton's third law can be declared an 'interaction involving a spouse of strength'. Be careful in talking about third legal pairs (often misleadingly called 'actions' and 'reactions'). Many students find this law the most difficult to understand. Back in the book on the table, there are three bodies involved: Earth, books, and tables. In this example, the pair of strength interactions are: In general, the pair of actions and reactions can be characterized as follows: Teaching Guidance for 14-16 Students will find that: (many students find an inverse proportion of the problem). Considering these points together leads to F comparable to ma or F = constant x ma. Mass measured in kg and acceleration in m/s/s but what about strength? If constants are equated with unity, then we define units of In SI system the force is measured in newton (symbol N), which leads to F=ma. Solid carbon dioxide is known as dry ice. It's sublime at -78°C to be cold gas. It is often used in theaters or nightclubs to produce clouds (looks a bit like smoke). Because it's denser than air, it stays low. This cools the air and causes moisture in the air to condense into small droplets - hence clouds. It is also useful in physics (and chemistry) laboratories. The Institute of Physics has kindly produced this video to explain how dry ice formed. Dry ice safety can be dangerous if not handled properly. Wear eye protection and challenge-style leather gloves when making or handling solid carbon dioxide. Using Dry Ice has many uses. In addition to just watching it sublimely, you can also use it for cloud space, dry ice chips, and cooling theistors and metal wire resistors in resistance experiments. It can also be used in experiments related to gas laws. Getting dry ice There are two main methods to get dry ice. 1. Using CO2 cylinders It is possible to make solid snow with expansion before lessons begin and store it in a wide-necked flask. Remember that the first production of solid carbon dioxide from the cylinder may not produce very much, since the cylinder and its attachment must be cooled. What kind of cylinder, where can I get CO2, and how much does it cost? CO2 gas cylinders should be equipped with a dipping tube (this is also called a 'siphon type' cylinder). This allows you to extract from the bottom of the cylinder so that you get CO2 in liquid form, not steam. NOTE: A plain black finish to the cylinder indicates that it will supply steam from above the liquid. A cylinder with two white stripes, diametrically opposite, indicates it has a siphon tube and is suitable for making dry ice. A cylinder from Oxygen UK will cost you around £80 a year for cylinder rental and around £40 each time you need to fill it. (Refills can be reduced by filling the cylinders of your chemical department at the same time.) Don't be tempted to get a small cylinder, it will run out too soon. If the school has its own CO2 cylinder there will be no rental fee, but you should check it from time to time (along with a fire extinguisher inspection). Your local fire station or their supplier may prove a good source for refills. Cleapss leaflet PS45 Rechargeable CO2 cylinders provides a list of CO2 suppliers. Attachment of dry ice to cylinders Dry ice disks can be made using attachments that match directly to carbon dioxide cylinders with siphon tubes. Section 13.3.1 of the CLEAPSS Laboratory Handbook describes the use of these attachments (sometimes called Snowpacks or Jetfreezers). This form is most useful for continuous cloud space and friction pieces You can buy Snowpack dry ice makers from Scientific and Chemical. The product number is GFT070010. 2. Buying blocks or pellets Solid carbon dioxide blocks or granules can be obtained quite easily with searches on the Internet. Local stage supply stores or universities may be able to help. It usually comes in expanded foam packaging; You can store it in this package in a deep freeze for several days. Dry ice pellets come in sle large batches. However, they have a number of uses in science lessons so it's a good idea to try to coordinate different teacher activities to make the most of your bulk purchases. Purchase.

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