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REVIEW ARTICLE

MEASUREMENT OF CENTRIPETAL FORCE WITH HIGH PERCENTAGE ACCURACY USING FORCE SENSOR AND PHOTO-GATE

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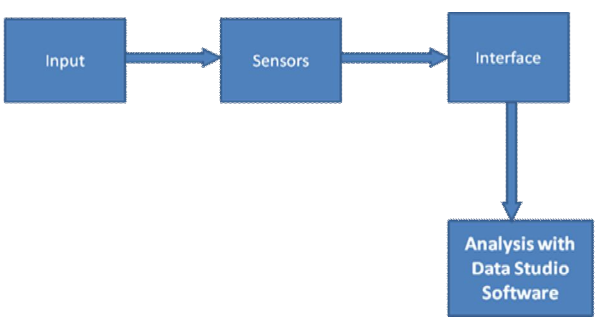
This paper describes the experimental work to measure the centripetal force using a force sensor and a photo-gate, and analysis with data acquisition software. The result of this experiment provides high percentage accuracy in the measurement of centripetal force; importance of sensors to analyze the force and velocity in order to obtain accurate measurements

Key words: Centripetal Force, Force Sensor, Photo-gate, Interface-500, Data Acquisition Software and Percentage Error

INTRODUCTION

The conventional way to measure the centripetal force of a body involves the swing of mass (es) above the head leads towards the difficulty in the execution and also the unavailability of the data to understand the relationship of the centripetal force with mass, velocity and radius. These difficulties are removed by the adopting a modern experimental technique by using sensors to measure the centripetal force and velocity of the body as rotates.



1. FORCE SENSOR

Force sensor is a device which can measure force. It is designed to be used with a PASCO *Science Workshop* Computer Interface 500. This version of the force sensor has an output between -8 volts and +8 volts and a range between -50 newtons and +50 newtons. In other words, it produces -8 volts for -50 newtons, 0 volts for "zero" force, and +8 volts for +50 newtons. (A push is considered to be positive, and a pull is considered to be negative.) The sensor has strain gauges mounted on a specially designed "S-bend beam". The beam has built-in over-limit protection so it will not be damaged if a force greater than 50 newtons is applied.

1.1. Calibrating the Economy Force Sensor

The Economy Force Sensor is designed to produce approximately zero volts when it is "zeroed". A change in force of one newton causes a change in output voltage of 160 millivolts (0.160 V); therefore, the sensor does not need to be calibrated. Instead, the voltage can be converted directly into force. For example, after the sensor is "zeroed", an output voltage of 0.160 volts equals a force of one newton, a voltage of 1.60 volts equals a force of 10 newtons, and so on. In the same way, a voltage of -1.60 volts equals a force of -10 newtons (in other words, a pull of 10 newtons). However, you can calibrate the sensor to learn about the process of calibration. All calibrations assume that the sensor produces an output voltage that is linear with respect to the input signal. Calibration is done by setting up two calibration situations (such as "no force" and a known force), measuring the input signal in each situation in comparison to a known standard, and entering the readings.

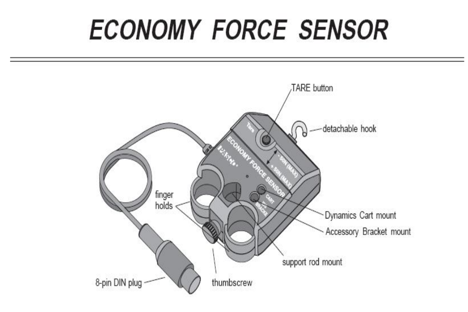


Fig.1. Force Sensor (Block Diagram must be given)

1.2 Use of Force Sensor or its (related work)

- Measure the force of a fan cart.
- Measure the centripetal force of a swinging pendulum, and compare the force to the speed, length, and mass of the pendulum.
- Measure the change in mass of liquid nitrogen as it vaporizes versus the energy input to vaporize the liquid nitrogen.
- Measure fluid drag forces on objects of various shapes in a wind tunnel.
- Measure the net force acting on a pair of harmonic oscillators.
- Study damped and undamped harmonic motion using a mass and spring system.

Newton's Third Law: Impulse/Collision

The impulse during a collision equals the change in momentum during the collision:

F□t = □mv

Component of Force on an Inclined Plane Newton's Second Law: Pushing and Pulling a Cart Tension
Newton's Second Law: Constant Force
Newton's Second Law: Friction
Work-Energy Theorem: W = □KE

1.2. Specifications

Output voltage: +8V for +50 newtons (pushing)
-8 V for -50 newtons (pulling)
Output noise: ±2 millivolts
Force slew rate: 30 newtons/millisecond
Bandwidth limit: 2 kilohertz
(internal low pass filter)
Output drive: 12 meters of cable without instability.
Beam deflection: 0.28 mm

2. PHOTOGATE HEAD

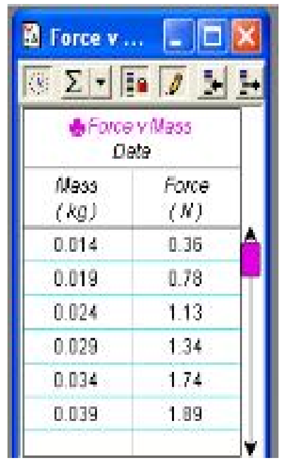
Photo gate basically measures or detects the motion of the body/mass(es), in other words measures the velocity of the masses. The *Pasco Model ME-9498A* photo gate head has a narrow infrared beam and a fast fall time that provide very accurate signals for timing. When the infrared beam b/w the source and detector is blocked, the o/p of the photo gate is LOW; and the LED on the photo gate goes ON. When the beam is blocked, the o/p is high and LED is OFF.

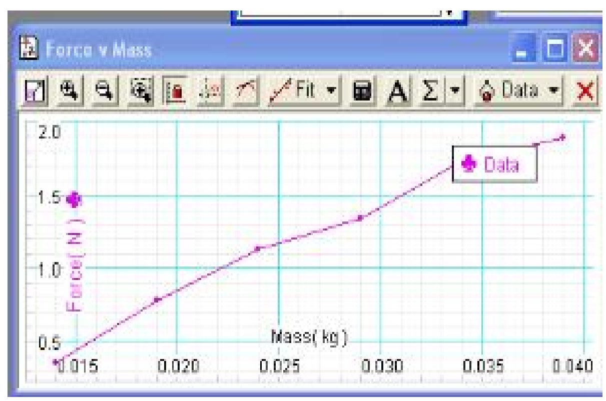
EXPERIMENTAL SETUP

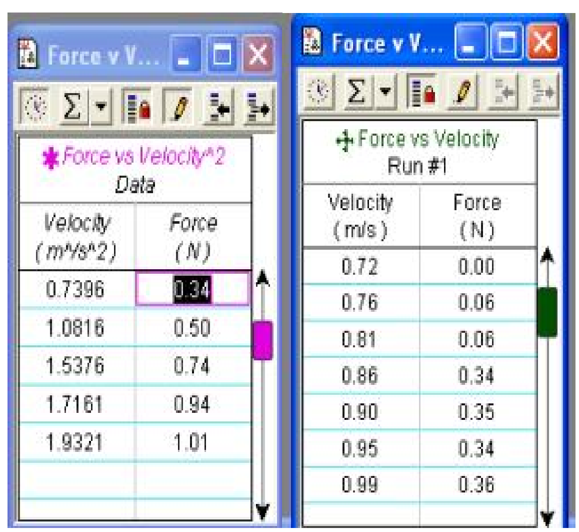
Traditional experiments in this area involve the swing of masses above the head. The traditional approach is difficult to execute and data is rarely sufficient for an understanding of relationship of the centripetal force with mass, velocity and the radius. This centripetal force apparatus remove these difficulties by using sensors to measure the force and velocity of the mass as rotates.

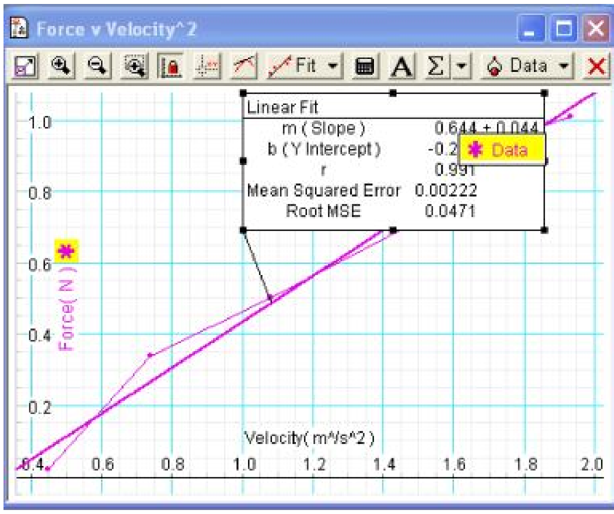
To "zero" the sensor, press and then release the tare button. When the tare button is pressed, the voltage from the sensor will be set to approximately zero volts.

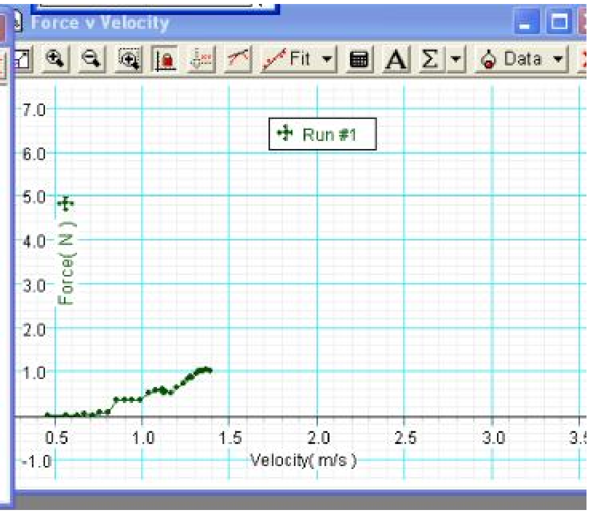
Note: You can also zero the sensor while a force is applied to the sensor. For example, if you want to measure the *change* in force during an experiment, set up the experimental equipment as needed, and tare the sensor at the beginning of the experiment before taking data. The sensor can maintain its "zeroed" condition for more than thirty minutes.

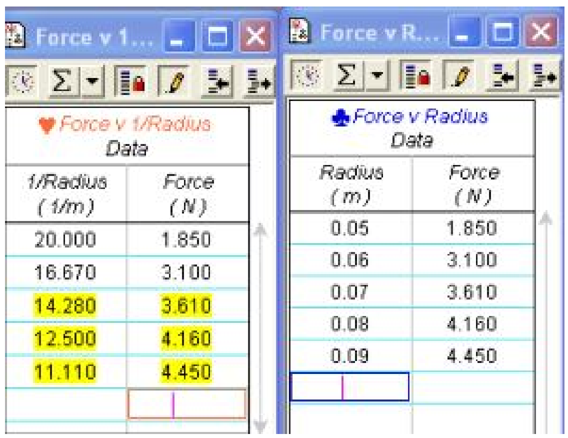










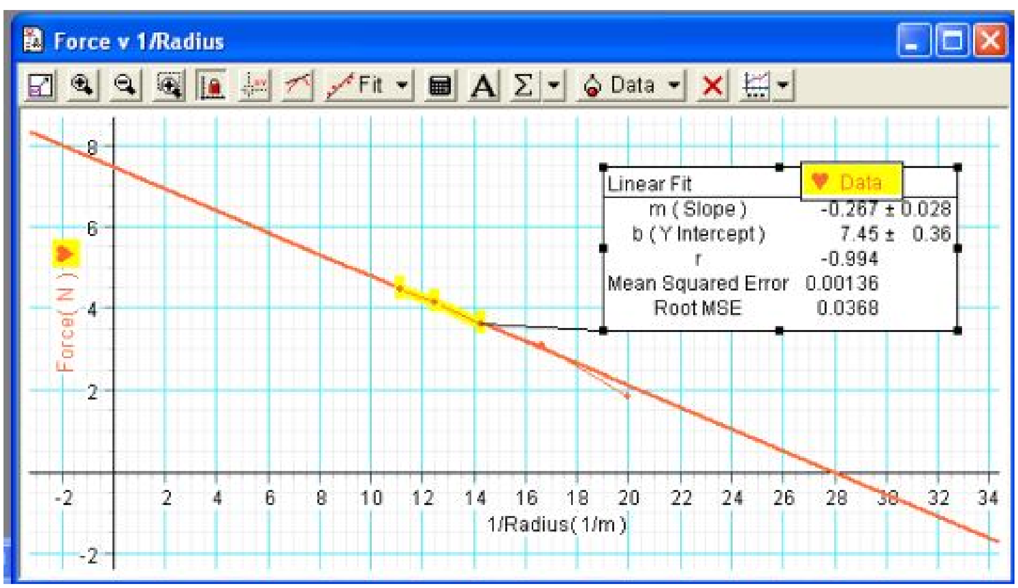


Force v 1/Radius Data

1/Radius (1/m)	Force (N)
20.000	1.850
16.670	3.100
14.280	3.610
12.500	4.160
11.110	4.450

Force v Radius Data

Radius (m)	Force (N)
0.05	1.850
0.06	3.100
0.07	3.610
0.08	4.160
0.09	4.450



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