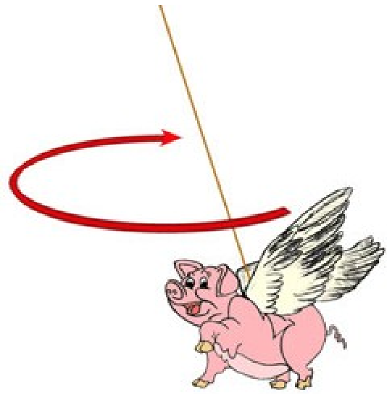


Flying Pig

P4-2165

BACKGROUND:

The Flying Pig provides students with a fun way to study circular motion. The pig and its string trace a conical pendulum and allow a perfect opportunity for calculations and measurements of circular motion.

The instructions included below can be altered to suit your students' abilities and skills. You might consider doing the pre-lab activity together, especially for students with less algebra and trigonometry experience.

Students should be familiar with forces, specifically centripetal force, and how it is calculated. Students should also know the definitions of the fundamental trigonometric functions and how they can be used to find the sizes of parts of a right triangle.

$$F_c = \frac{mv^2}{r}$$

SETUP INSTRUCTIONS:

1. Unscrew the battery cover and insert two AA batteries. (Do not use rechargeable batteries.) Replace the cover.
2. Gently pull the wings outward until they lock.
3. To activate the wings, use the on-off switch located on the pig's side.
4. The hanger may be permanently screwed to the ceiling, as shown on the box, or you may hang the pig from a Magnetic Ceiling Hook (P4-2166). In either case, it is best to have a rotating pivot, such as a fishing swivel, to avoid twisting the string.

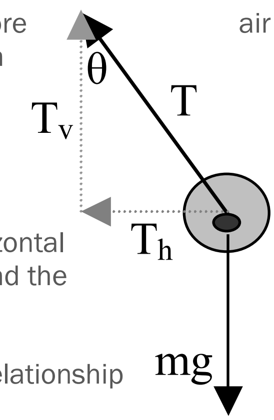
5. Attach the string to the hook on the pig, just behind the wing mechanism.

LAUNCH INSTRUCTIONS:

1. Hold the pig by its body, so that the string is about 30° from vertical.
2. Turn on the motor.
3. Give the pig a slight shove in a direction that is tangent to the circle where it will fly.
4. If the pig does not fly in a circle for 10 seconds, carefully catch it and try the launch again.

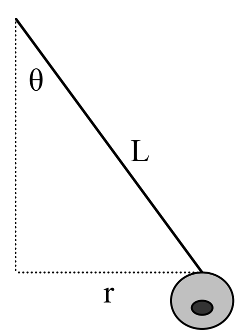
PRE-LAB INSTRUCTIONS:

Students will calculate the theoretical speed of the pig, to be compared to the pig's actual speed, measured in the activity. (Solutions are in parentheses.)



1. Draw a diagram of the flying pig, showing the forces that act on it. Ignore air resistance. (Forces will include the pig's weight, mg, and the tension in the string, T, as shown.)
2. With dashed lines, draw the vertical and horizontal components of T, and label the angle θ between T and the vertical.
3. In what direction, horizontal or vertical, does the pig accelerate? (Horizontal only.) What does this tell you about the net vertical force on the pig, and the relationship between mg and T_v? (T_v=mg.)
4. Which force in the diagram is the centripetal force? (T_h) What is the relationship between T_h , T_v and θ? ($T_h = T_v \tan \theta$.)
5. Write an equation that shows the relationship between mv^2/r to T and θ. ($\frac{mv^2}{r} = T_v \tan\theta$)
6. Refer to your answer in step 3 and make a substitution in the equation to eliminate T_v.
   ($\frac{mv^2}{r} = mg \tan\theta$)
7. Solve the equation for v. ($v = \sqrt{rg \tan\theta}$) Notice that the mass term cancels.

ACTIVITY INSTRUCTIONS:



1. When the pig is flying in a consistent circle, measure the radius of the circle, *r*.
2. Determine the angle that the string makes from vertical, θ. If students are familiar with basic trigonometric functions, this can be determined using the sine function. Students may also attempt to measure the angle directly with a protractor.

where L is the length of the string.

$$\sin(\theta) = \frac{r}{L} \qquad \theta = \sin^{-1}(\frac{r}{L})$$

3. Calculate the theoretical velocity, using the equation you developed in step 7 of the pre-lab with the measured values for r and θ.
4. Measure the speed of the pig. To do this, measure the time it takes to complete 10 revolutions, and divide by 10 to find the time for a single revolution, t. The linear distance covered in that time is the circumference of the circle, $2\pi r$. Velocity is found by dividing the distance by the time to cover that distance.

$$v = \frac{2\pi r}{t}$$

5. Compare the two velocity values. Suggest sources of error.

ACKNOWLEDGEMENTS:

Thank you to Paul Robinson and Paul Hewitt for their assistance in the development of this product and its accompanying instructions. The lab is currently in development for inclusion in the *Conceptual Physics Lab Manual*.

RELATED PRODUCTS:

Rotating Stool (P3-3610). A sturdy lab stool with a rotating seat, useful for a wide range of rotational demonstrations.

Rotational Accelerometer Accessory (P3-3612). Attach two liquid accelerometers to the top of the Rotating Stool to show the centripetal acceleration in two different locations.

Digital Stopwatch/Timer (52-3200).

Wood Meter Stick (P1-1070)

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