Playground Physics

Annotation
This lesson makes use of playground equipment including swings, a merry-go-round, slide, and seesaw to understand some basic principles of physics such Newton's Law of Motion (especially 1^{st} and 2^{nd}), center of gravity, momentum, rotational inertia, torque, and the coefficient of sliding friction. The lesson is to be conducted outside on a playground and requires a Vernier force probe for one of the four activities.

Primary Learning Outcome:
After the lesson is taught, students should be able to understand: how sliding friction prevents us from moving down a slide without a push, how the pivot point on a seesaw affects torque, how the merry-go-round demonstrates rotational inertial, and how a swing is an example of a pendulum.

Additional Learning Outcomes:
Students should be familiar with Vernier probe and CBLss.

Georgia Performance Standards:
SP1. Students will analyze the relationships between force, mass, gravity, and the motion of objects.
SPS8. Students will determine relationships among force, mass, and motion.
SP3. Students will evaluate the forms and transformations of energy.

Total Duration:
1.25 hours

Materials and Equipment:
1) Vernier Probe
2) CBL
3) Seesaw
4) Merry-go-round
5) Swing
6) Slide
7) Calculator
8) Tape measure
9) Stopwatch
10) Tennis ball
11) Protractor

Technology Connection:
Vernier Probe and CBL

***Assessment:**
Students will answer questions and fill out tables provided with the worksheet.

PLAYGROUND PHYSICS

PURPOSE: To investigate the physics of playground equipment.

BACKGROUND INFORMATION:

Playground equipment operates according to the laws of physics. Pay particular attention to the following topics:

1. Newton's Law of Motion (especially 1st and 2nd)
2. Center of Gravity
3. Momentum
4. Rotational Inertia
5. Torque
6. Coefficient of Sliding Friction

MATERIALS AND EQUIPMENT:

Swing	Stopwatch	Calculator
Seesaw	Low G accelerator (CBL)	G-force device
Merry-go-round	Metric tape measure	Tennis ball
Slide	Protractor	

Your mass: ________________kg Your weight: ________________ N

SWINGS:

1. Have one partner get on the swing while another watches. Gets the swing moving without help from anyone else.

   a) What do you have to do (mechanically) to get the swing in motion?

   b) Use physics to explain how your body motion operates the swing. (What produces the force?)

2. Use the Vernier force probe to determine the G-force exerted by a swing. ___________ G-force
3. Calculate you maximum weight on the swing. _____________________N
4. Measure the length of the chain (the length of a pendulum) from the top of the chain to the bottom of the swing seat. ___________________ m
5. Get the swing going, and then try to remain as upright as possible to avoid affecting the swing. Time 5 complete swings (over and back is one swing). Determine the time for one swing (called a period). Repeat with a heavier mass.

Partner	Time for 5 swings (sec)	Period (/s)
Lighter Partner		
Heavier Partner		

6. If possible, find a swing with a shorter chain (or wrap a swing around the top of a bar to shorten it). Repeat steps 4 and 5.

Partner	Time for 5 swings (sec)	Period (/s)
Lighter Partner		
Heavier Partner		

7. Which seems to have more effect on the period of a swing; the mass of the person in the swing or the length of the chain?

8. Calculate the acceleration due to gravity.

SLIDE:

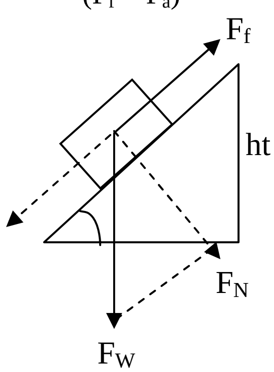
1. Measure the height of the slide (the bottom of the slide is where it levels off, not the ground) Measure the length of the actual, slide stopping where it levels off (this is the hypotenuse of the triangle). Measure the angle of the slide (from where it levels off). Calculate tanθ.

Height (m)	Length (m)	Measured angle	Calculated angle	Average angle

2. The tangent of the slide represents the lowest coefficient of friction that should allow an object to slide down without any force other than gravity. Calculate it. ______________________

3. Calculate the coefficient of sliding friction using your weight in Newtons $\mu = \frac{F_f}{F_n}$ and the average angle (F_f) that you found. Do not use tanθ.

($F_f = F_a$)



4. Should you be able to slide without pushing?

5. Have a partner slide down the slide. Is it necessary to use a pushing force, or does gravity provide sufficient force?

MERRY-GO-ROUND (MGR):

1. Measure the radius from the outer rim to the center. Record. ________________m

2. Measure the radius from the outer rim to a point about halfway toward the center. ________________m

3. Calculate the circumference of the circle for both radii. ____________m (outer) _____________m (inner)

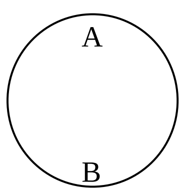
4. Have a person sit on the outer rim and another at the midway point. Get the MGR moving (assume a constant velocity). Measure the time for three complete turns. Calculate average speed at each place where a person is sitting.

Distance from Center	Time for 3 turns (sec)	Time for 1 turn (sec)	Average Speed (m/s)
Midway			
Outer Rim			

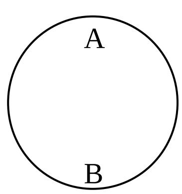
5. Who experiences the faster ride?

6. Have two team members sit on opposite sides of the MGR. Push to get the MGR moving. Have one team member toss a tennis ball to the person on the opposite side while the MGR is in motion. Do you experience any difficulties? __________ Explain what they are.

   a) Draw a path of the ball as seen by an observer on the ground.



   b) Draw a path of the ball as seen by the person at point B.



7. Explain the cause of any differences in the observed path of the tennis ball.

8. Have two partners stand on either side of the MGR. Get the MGR in motion and have the two team members slowly lean out as far from the MGR as possible. Note any changes in the speed of the MGR.

9. While the MGR is still in motion, have the two partners pull slowly in toward the center of the MGR. Note any changes in the speed of the MGR.

10. Explain the changes when people move in and out of the MGR while it is in motion. (What affects the speed?)

11. Did the people notice any difficulty in pulling back from an extended position while the MGR was in motion? What force opposed the inward pull you were exerting?

SEE SAW:

Explain the role of torque in the operation of a see saw. (Use a diagram to support you explanation.)

Measure the distance from the pivot point of the see saw to the place where a child would sit to ride. Assume the child has a mass of 25 kg. How far from the pivot would a 38 kg child have to sit to achieve rotational equilibrium?