**Force and Motion – Newton’s 2nd Law**

In these activities we will use a motion sensor to measure the acceleration of an object subject to various forces. The acceleration can be related to the forces acting on the object by Newton’s 2nd law of motion, Σ*F = ma.*

Inclined Plane

θ

h

d

motion sensor

A cart rolls down an inclined plane as shown above. Identify all of the forces acting on the cart. Show these in a ‘force diagram’.

If friction can be neglected, then you should find that the net force acts down the inclined plane and is given by mg sinθ. Then Σ*F = mg* sinθ = *ma*, or *a* = *g* sinθ = *gh/d*, where *h* is the elevation of the end of the incline and *d* is the length of the incline.

Use the motion sensor to measure the acceleration for a given elevation *h*. If the acceleration is constant, then what should be the shape of the velocity versus time curve? Determine *a* from the slope of this curve. How does this value compare with that calculated from Newton’s 2nd law?

What effect should friction have on your results?

Repeat your measurements for one or two other angles. Is *a* proportional to *h* as predicted?

Half-Atwood Machine

m1

motion sensor

m2

Identify all the forces acting on the masses m1 and m2 in the setup above. If the mass of the pulley and friction in the pulley and wheels of the cart can be neglected, then the net force acting on the two masses as a system is just the weight of m1. This force accelerates both masses, so

ΣF = m1g = (m1+m2)*a*, or *a* = m1g/(m1+m2)

Set up the experiment as shown in the diagram using m1 = 50 g. Measure *a* and compare with the value calculated from Newton’s 2nd law. How do these values compare?

What effect would friction and pulley mass have on your measured acceleration (increase, decrease, no effect)?

Friction

Consider a block sliding to rest on a level surface.

Identify the forces acting on the block as it slides. Show that the net force acting on the block is the frictional force Ff. Then Ff = m*a*.

By definition, the coefficient of friction between the block and surface is µ = Ff/Fn, where Ff is the frictional force and Fn is the normal force on the block. Since the surface is level, then Fn = mg and µ = m*a*/mg = *a*/g.

Shove a block away from or towards the motion sensor and measure its deceleration after you release it. Use this to calculate µ.

*Question*: If you shove a heavier block with the same roughness along the table, does the magnitude of its deceleration increase, decrease, or remain the same?

Check your answer by using a significantly heavier block (or two stacked blocks, using clay to keep them together).

Pick a block and/or surface that has a different roughness. Do you expect µ to be larger or smaller? Check your prediction by measuring µ.