Smooth Variable Ramp

Apparatus

smooth variable ramp, small trolley or toy car, spring balance, protractor

Action

The students attach the trolley to the spring balance and place the trolley on the ramp. They then adjust the angle of the ramp and observe how the reading on the balance changes. They should draw a free body diagram showing the forces parallel and perpendicular to the ramp, and comment on the relative sizes of these forces.

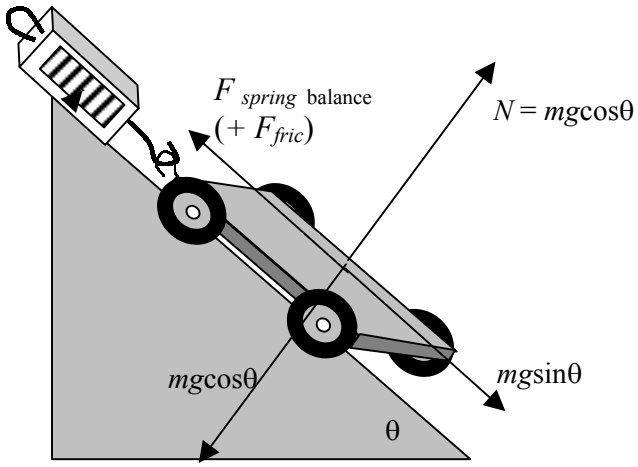
The Physics

The forces acting on the trolley are the normal force, gravity, the force due to the spring balance and friction. Decomposing these into components along the ramp and perpendicular to the ramp gives:

Forces perpendicular to ramp: N and $mg\cos\theta$, which are equal.

Forces along the ramp: $mg\sin\theta$, the force due to the spring balance and friction.

The force due to the spring balance plus friction will be equal to $mg\sin\theta$, the friction should be very small so the spring balance should read (approximately) $mg\sin\theta$. This will increase as the angle increases, and will be equal to mg when the ramp is vertical.



Accompanying sheet

Smooth Variable Ramp

Draw a free body diagram showing the forces acting on the trolley.
What are the components of the forces
acting parallel and perpendicular to the ramp?

Is the force on the trolley from the spring balance equal to $mg\sin\theta$?
What happens to the force needed to keep the trolley stationary on the ramp
as the inclination of the ramp is increased?