1. Circular Motion on an Inclined Track

Consider a car of mass m moving on a circular trajectory of radius R on an inclined track. The track is inclined at an angle θ with respect to the horizontal direction.

Suppose the surface of the inclined track is frictionless.

(a) Draw the free-body diagram for the car. Indicate the direction in which the car is accelerating.
(b) Define the direction parallel to the direction of acceleration as x-axis and the direction perpendicular to it in the plane of the diagram as y-axis. Write down the x and y components of the equation of motion, $m\vec{a} = \vec{F}_{net}$, from the free-body diagram.
(c) Calculate the speed at which the car must move to avoid sliding up or down the track.

Now, suppose the surface of the inclined track has a coefficient of static friction $\mu \neq 0$.

In general, the presence of friction permits a range of speeds: $v_{min} < v < v_{max}$. The car slides down the track for $v < v_{min}$ and slides up for $v > v_{max}$ (can you explain why?).

(d) Consider $v = v_{max}$. Add the force of friction to the free-body diagram of part (a) (you should be careful about the direction of the frictional force!).
(e) Write down the x and y components of the equation of motion, $m\vec{a} = \vec{F}_{net}$, from the new free-body diagram.
(f) Obtain an equation of v_{max} in terms of g, R, θ, and μ.

2. Energy and Momentum of Fan Cart

A fan cart of mass 1 kg initially has a velocity of $\langle 1, 0, 0 \rangle$ m/s. Then the fan is turned on, and the air exerts a constant force of $\langle -1, 0, 0 \rangle$ N on the cart for 2 seconds.

(a) What is the change in momentum of the fan cart over this 2-second interval?
(b) What is the change in kinetic energy of the fan cart over this 2-second interval?
(c) What is the total change in position of the fan cart over this 2-second interval?