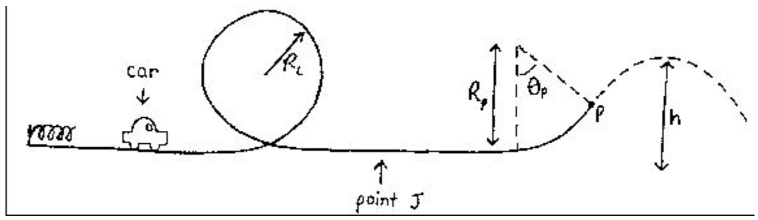
QP6



A child's toy consists of a car on a frictionless track with a circular loop of radius R_L, as shown in the figure. The car is being pushed against the spring (so that the spring is compressed by distance x) and then released. The car is linked to the track so that it slides along the track but cannot fall off. The track ends at point P, and the section of track just before this point is curved with radius R_P as shown. The car is free to fly through the air after leaving P. The car has mass M and the spring has spring constant k.

For parts a - d, assume that the car starts at rest against the spring with the spring compressed by distance x, where x is large enough so that the car has more than enough velocity to go around the loop. Your answers should be in terms of g, k, M, R_L, R_P, x, and θ_P.

a) (2 points) What is the normal force of the track on the car at the top of the loop?

b) (2 points) After the car has let the track at point P, what is the maximum height h reached by the flying car?

Suppose now the child spills jam on the track just after the loop, at point J as shown in the diagram. The jam has coefficient of friction μ and the spill has length d. Your answers should be in terms of d, g, k, M, x and μ.

c) (1 point) What is the velocity of the car after it leaves the spill?

d) (1 point) For what minimum value of d will the car get stuck?

For parts e and f, you are to determine under what conditions the car can make it around the loop. Your answers should be in terms of g, k, M and R_L.

e) (2 points) What is the minimum compression of the spring, x_{min} for the car to just barely reach the top of the loop?

f) (2 point) If the spring were given this minimum compression and the car wasn't linked to the track, at what height would the car fall off?