PHYS 101:General Physics1 KOÇ UNIVERSITY Fall Semester 2016

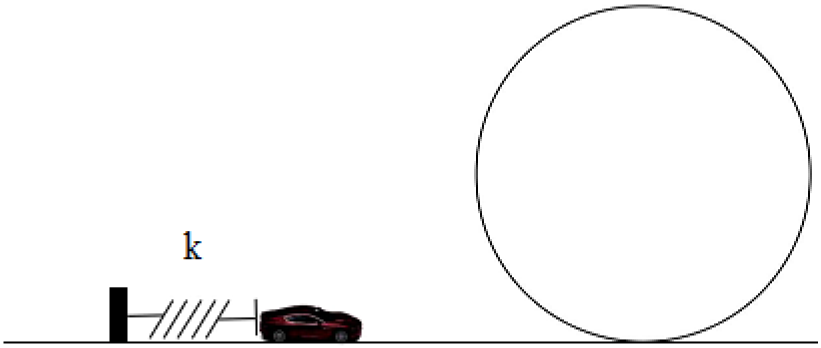
College of Sciences

Section 1 Quiz 5 November 18, 2016

Closed book. Duration: 20 minutes

Name: Student ID: Signature:

You are trying to launch a 100g slot car around the inside of a 1m diameter loop-the-loop using a spring with a natural (unstressed) length of 20 cm and a spring constant of 100 N/m. Assume the slot car is frictionless. Take the gravitational acceleration as g = m/s^2. What is the minimum amount you need to compress the spring in order for the car to make it around the loop without falling off?



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- You will lose credit if you don't show all relevant coordinate systems.
- You will lose credit if you don't draw all relevant free-body diagrams.
- You will lose credit if you use a conservation theorem without any explanation.
- You will lose credit for missing units.

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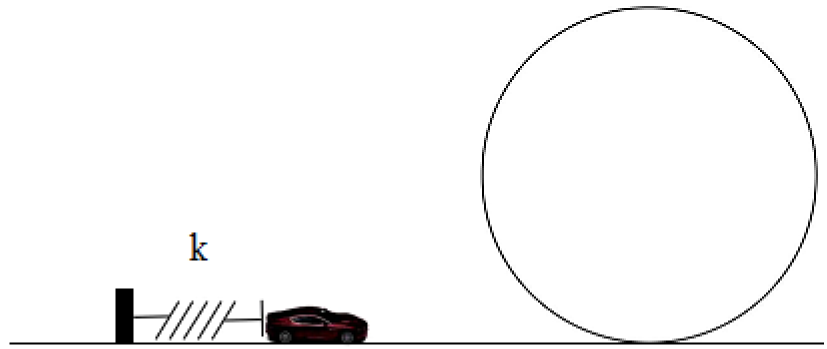
Section 2 Quiz 5 November 18, 2016

Closed book. Duration: 20 minutes

Name: Student ID: Signature:

You are trying to launch a 100g slot car around the inside of a 1m diameter loop-the-loop using a spring with a natural (unstressed) length of 20 cm and a spring constant of 100 N/m. Assume the slot car is frictionless. Take the gravitational acceleration as g = m/s^2. If you compress the spring all the way to the wall, what normal force will the track exert on the car at the bottom of the loop, just inside the circular portion?



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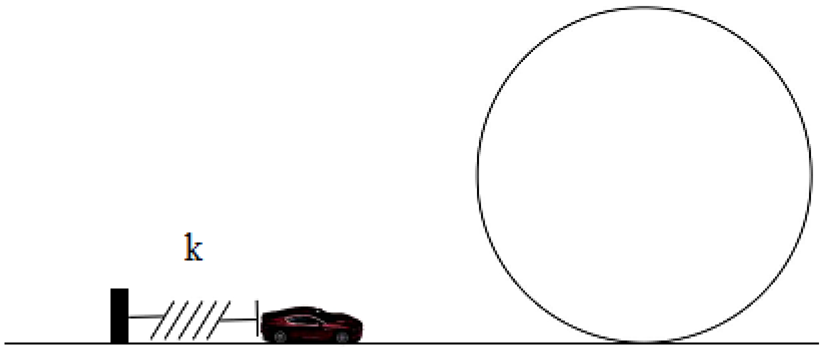
Section 3 Quiz 5 November 18, 2016

Closed book. Duration: 20 minutes

Name: Student ID: Signature:

You are trying to launch a 100g slot car around the inside of a 1m diameter loop-the-loop using a spring with a natural (unstressed) length of 20 cm and a spring constant of 100 N/m. Assume the slot car is frictionless. Take the gravitational acceleration as g = m/s^2. If you compress the spring all the way to the wall, what normal force will the track exert on the car at the top of the loop?



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PHYS 101:General Physics1   KOÇ UNIVERSITY   Fall Semester 2016

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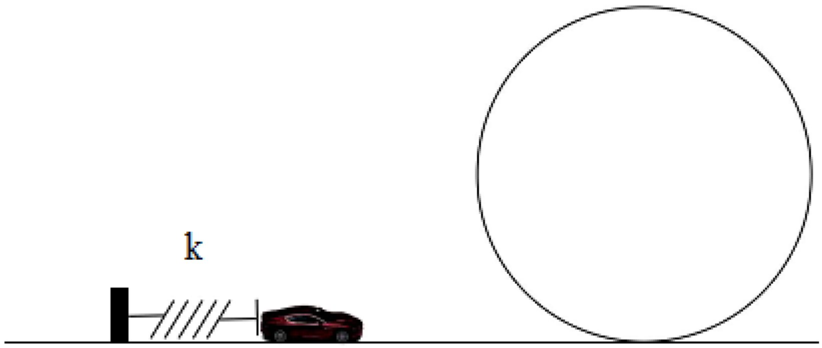
Section 4   Quiz 5   November 18, 2016

Closed book. Duration: 20 minutes

Name: Student ID: Signature:

You are trying to launch a 100g slot car around the inside of a 1m diameter loop-the-loop using a spring with a natural (unstressed) length of 20 cm and a spring constant of 100 N/m. Assume the slot car is frictionless. Take the gravitational acceleration as g = m/s^2. If you compress the spring all the way to the wall, what is the acceleration of the car when its velocity is purely in the upward (+y) direction?



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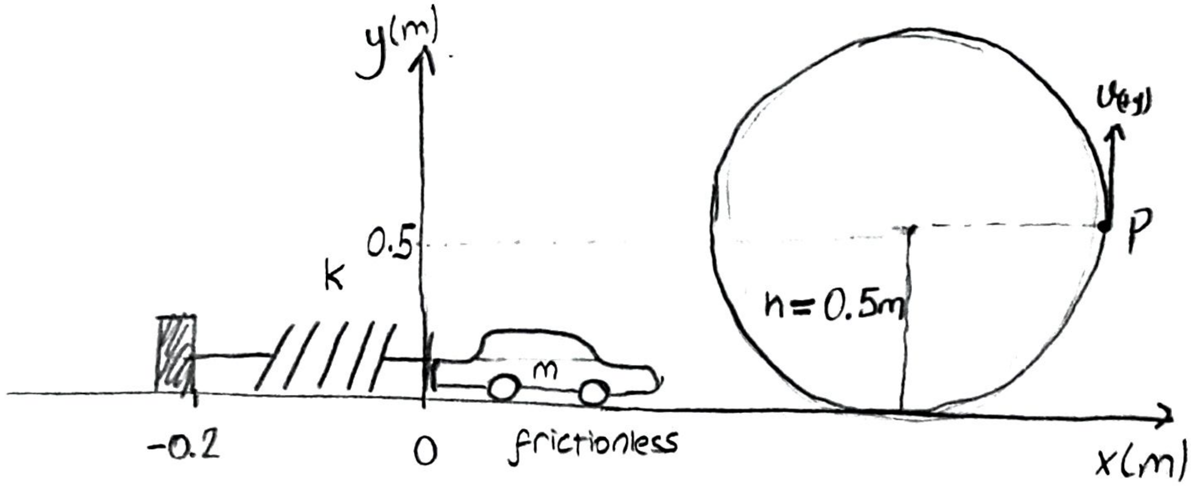
QUIZ 8&9 SOLUTIONS



(a) The car's velocity is purely upward when it reaches the point P. The elastic potential energy stored in spring will be converted into kinetic and potential energy with the total energy being conserved.

Therefore we write $\left(K_1 = 0,\ U_1 = \frac{1}{2}kx^2,\ K_2 = \frac{1}{2}mv_{(+y)}^2,\ U_2 = mgh\right)$,

$$\frac{1}{2}kx^2 = mgh + \frac{1}{2}m v_{(+y)}^2$$

$$\Rightarrow \quad v_{(+y)} = \sqrt{\frac{k}{m}x^2 - 2gh}$$

$$\Rightarrow \quad v_{(+y)} = \sqrt{\frac{(100\ N/m)}{(0.1\ kg)}(0.2\ m)^2 - 2\left(\frac{m}{s^2}\right)(0.5\ m)}$$

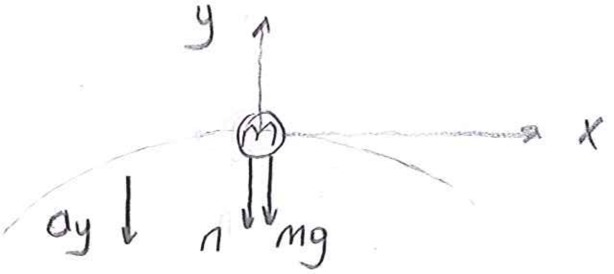
$$= 6.25\ m/s \quad \text{where } N:\ kg\frac{m}{s^2}.$$

The radial acceleration is thus,

$$a_{rad} = \frac{v_{(+y)}^2}{R} = \frac{(6.25\, m/s)^2}{0.5 m} = 78.1\ m/s^2$$

The tangential acceleration is the same as $g = m/s^2$, as there is only F_g along y direction.

(b) The minimum compression to make it around the loop corresponds to the minimum speed at top



$$\sum \vec{F} = m\vec{a}$$

$$\Rightarrow \quad -n - mg = -m\frac{v_m^2}{R}$$

normal force should be zero for minimum speed

$$\Rightarrow \quad v_m = \sqrt{gR}$$

Conservation of the mechanical energy gives

$$\frac{1}{2}k x_{min}^2 = mg2R + \frac{1}{2}m \underbrace{v_m^2}_{gR}$$

$$\Rightarrow \quad x_{min} = \sqrt{\frac{4gmR}{k} + \frac{gmR}{k}} = \sqrt{\frac{5gmR}{k}}$$

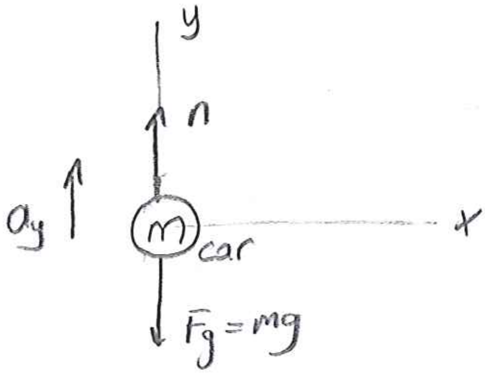
$$= \sqrt{\frac{5\left(\frac{m}{s^2}\right)(0.1\,kg)(0.5m)}{100\,N/m}} = 0.05\,m$$

(c) $\frac{1}{2}kx^2 = \frac{1}{2}mv_b^2 \Rightarrow v_b = \sqrt{\frac{k}{m}}\, x$

$$= \sqrt{\frac{100\,N/m}{0.1\,kg}}\,(0.2\,m)$$

$$= 6.32\,m/s$$

at the bottom of the loop



$$\sum \vec{F} = m\vec{a}$$

$$n - mg = m\frac{v_p^2}{R}$$

$$\Rightarrow n = m\left(g + \frac{v_p^2}{R}\right)$$

$$= (0.1\,kg)\left[\frac{m}{s^2} + \frac{(6.32\,m/s)^2}{(0.5\,m)}\right]$$

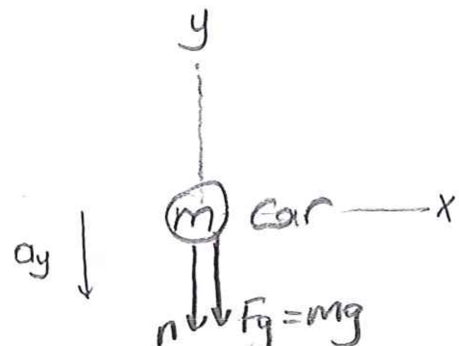
$$\cong 8.1\,kg \cdot \frac{m}{s^2} = 8.1\,N$$

(d) $\frac{1}{2}kx^2 = mg\underset{2R}{h} + \frac{1}{2}mv_t^2$

$$\Rightarrow \quad v_p = \sqrt{\frac{k x^2}{M} - 4gR} = \sqrt{\frac{100\,N/M\,(0.2m)^2}{0.1kg} - (m/s^2)(2\,m)}$$

$$= 6.16\ m/s$$

at the top of the loop



$$\Sigma \vec{F} = m\vec{a}$$

$$\Rightarrow \quad n + mg = m\frac{v_p^2}{R}$$

$$\Rightarrow \quad n = m\left(\frac{v_p^2}{R} - g\right)$$

$$= (0.1kg)\left[\frac{(6.16\,m/s)^2}{(0.5\,m)} - \frac{m}{s^2}\right]$$

$$= 7.50\ kg\frac{m}{s^2} = 7.50\ N$$