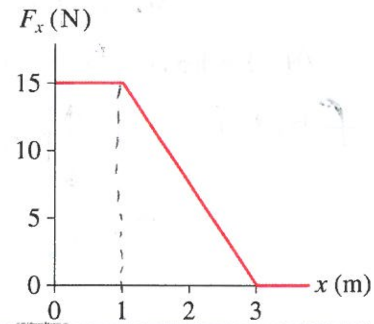
PINK
GREEN

# QUIZ 7, PHY 191 B, Blue, Friday, Oct 21, 2016 (20 pts)

**[see both sides of sheet!]**

## SHOW WORK CLEARLY OTHERWISE ZERO CREDIT!!

Question 1:
A 400 g particle moving along the $x$-axis experiences the force shown in the figure. The particle's velocity is 3.0 m/s at $x = 0$ m. What is its velocity at $x = 3$ m? (4pts)




ANSWER: ____________________

Use $\Delta K = W_{ext} \Rightarrow \frac{1}{2}m(v_f^2 - v_i^2) =$ Area under $F_x - x$ curve

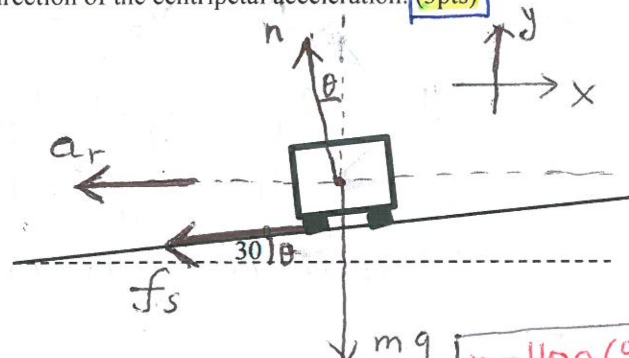
$\therefore \frac{1}{2}mv_f^2 = \frac{1}{2}mv_i^2 + [(15)(1) + \frac{1}{2}(2)(15)]$

| | | |
|---|---|---|
| $\frac{1}{2}(0.4)v_f^2 = \frac{1}{2}(0.4)3^2 + 30$ <br> $v_f = 12.6$ m/s | $\frac{1}{2}(0.5)v_f^2 = \frac{1}{2}(0.5)4^2 + 30$ <br> $v_f = 11.7$ m/s | $\frac{1}{2}(0.8)v_f^2 = \frac{1}{2}(0.8)5^2 + 30$ <br> $v_f = 10$ m/s |

Question 2: A car of mass 1000 kg rounds a curve of unknown radius on a road banked at 30⁰ to the horizontal, turning leftward as shown, with the maximum permissible speed such that it is on the verge of skidding outward (but it does not). The coefficient of static friction between the car and the road is 0.8.

USE $(f_s)_{max} = \mu_s n$!

a) Draw a free body diagram for the car. Indicate the direction of the centripetal acceleration. (3pts)




b) What is the magnitude of the normal force between the car and the road? (3pts)

DO NOT TILT X-Y AXES! (Do you see, why?)

USE $F_{net\,y} = ma_y \Rightarrow 0$

$n\cos\theta - f_s \sin\theta - mg = 0$, $f_s = \mu_s n$

$\therefore n = \dfrac{mg}{\cos\theta - \mu_s \sin\theta}$

| | | |
|---|---|---|
| $\therefore n = \dfrac{1000(9.8)}{\cos 30^\circ - 0.8\sin 30^\circ} = 21029$ N | $n = \dfrac{1200(9.8)}{\cos 15^\circ - 0.7\sin 15^\circ} = 14986$ N | $n = \dfrac{1100(9.8)}{\cos 20^\circ - 0.9\sin 20^\circ} = 17060$ N |

b) What is the magnitude of the centripetal (or radial) acceleration? (3pts)

USE $F_{net\,x} = ma_x = ma_r$

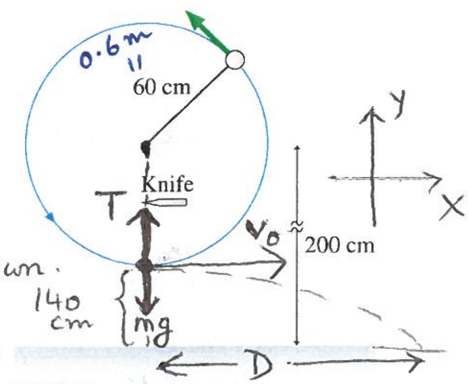
$n\sin\theta + f_s\cos\theta = ma_r \Rightarrow a_r = \dfrac{n}{m}(\sin\theta + \mu_s\cos\theta)$, $f_s = \mu_s n$

| | | |
|---|---|---|
| $a_r = \dfrac{21029(\sin 30^\circ + 0.8\cos 30^\circ)}{1000}$ <br> $= 25.1$ m/s² | $a_r = \dfrac{14986(\sin 15^\circ + 0.7\cos 15^\circ)}{1200}$ <br> $= 11.7$ m/s² | $a_r = \dfrac{17060(\sin 20^\circ + 0.9\cos 20^\circ)}{1100}$ <br> $= 18.4$ m/s² |

Turn sheet over

$\Rightarrow 0.1\,kg$

Question 3: A 100 g ball on a 60 cm string is swung in a vertical circle about a point 200 cm above the floor. The tension in the string when the ball is at the very bottom of the circle is 6.0 N. A very sharp knife is suddenly inserted, as shown in the figure, to cut the string directly below the point of support.




a) What is the launch velocity (magnitude and direction) of the ball at the bottom of the circle at the instant the string is cut? (3 pts)

$v_0$ is purely horizontal, pointing right as shown.

At bottom, the instant before string is cut,

fbd is ↑T, ↑$a_r$, ↓mg, which yields $T - mg = \frac{mv_0^2}{r}$

| | | |
|---|---|---|
| $\Rightarrow 6 - 0.1(9.8) = \frac{0.1\,v_0^2}{0.6}$ $\Rightarrow v_0 = 5.5\,m/s$ | $1.5 - 0.1(9.8) = \frac{0.1\,v_0^2}{0.6}$ $\Rightarrow v_0 = 1.8\,m/s$ | $3 - 0.1(9.8) = \frac{0.1\,v_0^2}{0.6}$ $\Rightarrow v_0 = 3.5\,m/s$ |

b) How far to the right of where the string was cut does the ball hit the floor? (4 pts)

Straight-up projectile problem!

x: $\Delta x = v_{0x}\Delta t + \frac{1}{2}a_x(\Delta t)^2$ yields

$D = v_0 \Delta t$ —— (i)

y: $\Delta y = v_{0y}\Delta t + \frac{1}{2}a_y(\Delta t)^2$

$-1.4 = \frac{1}{2}(-9.8)(\Delta t)^2 \Rightarrow \Delta t = 0.535\,s$ —— (ii)

PLONK (ii) into (i):

| | | |
|---|---|---|
| $D = (5.5)(0.535) = 2.9\,m$ | $D = (1.8)(0.535) = 1\,m$ | $D = (3.5)(0.535) = 1.9\,m$ |