18

Name: ____________
Date: ____________

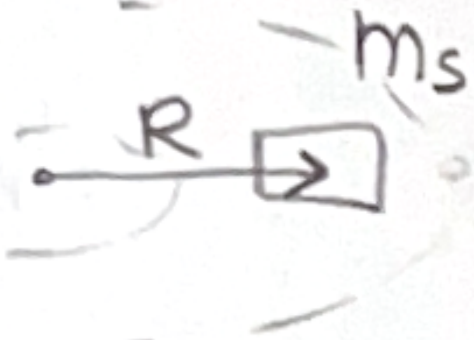
Circular Motion Practice 3

(Solutions posted)

Show the problem-solving steps.

1. A suitcase (22 kg) is on a baggage claim carousel, moving at a constant speed around the circular curvature at the end. The radius of the suitcase's circular path is 1.8 m. The coefficient of static friction between the suitcase the the rubber surface of the carousel is 0.8, and the coefficient of kinetic friction is 0.6.

a. If the suitcase is making the turn at a speed of 2.5 m/s, what is the magnitude and direction of the force of static friction acting on the suitcase?



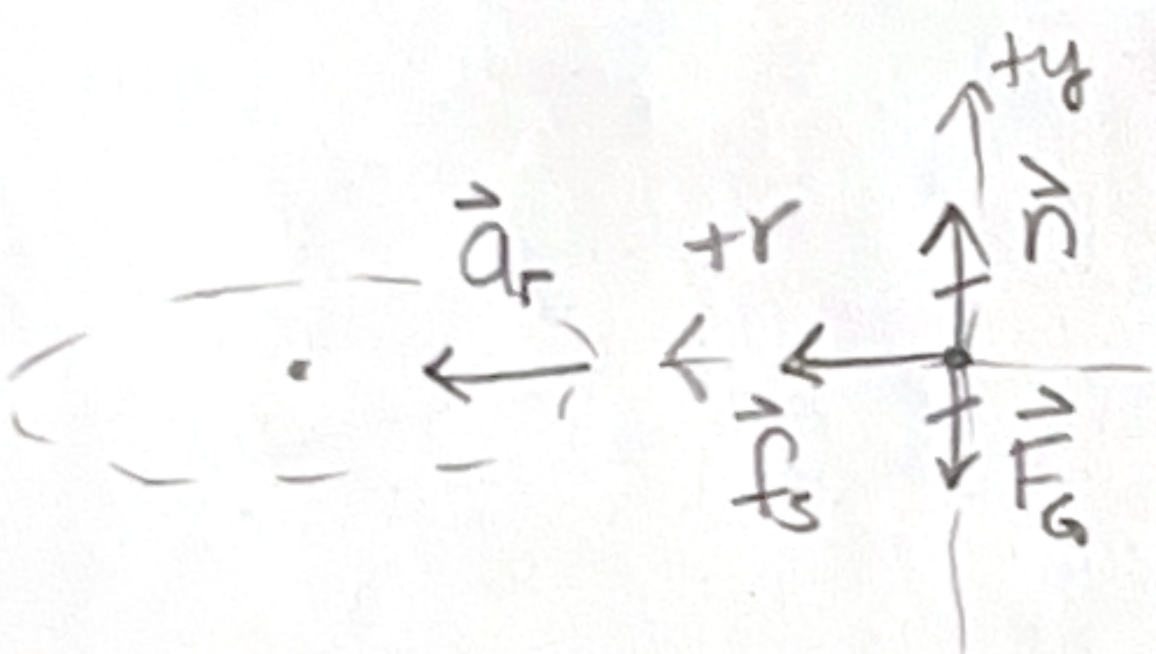
m_s $V_t = 2.5\,m/s$

$f_s = ?$

$\mu_s = .8$

$\mu_k = .6$

$\vec{F}$	F_r	F_y
$\vec{n}$	$n_r = 0$	$n_y = +n$
$\vec{F_G}$	$F_{Gr} = 0$	$F_{Gy} = -mg$
$\vec{f_s}$	$f_{sr} = +f_s$	$f_{sy} = 0$



Find f_s: $a_r = \frac{\Sigma F_{on\,s\,r}}{m_s}$

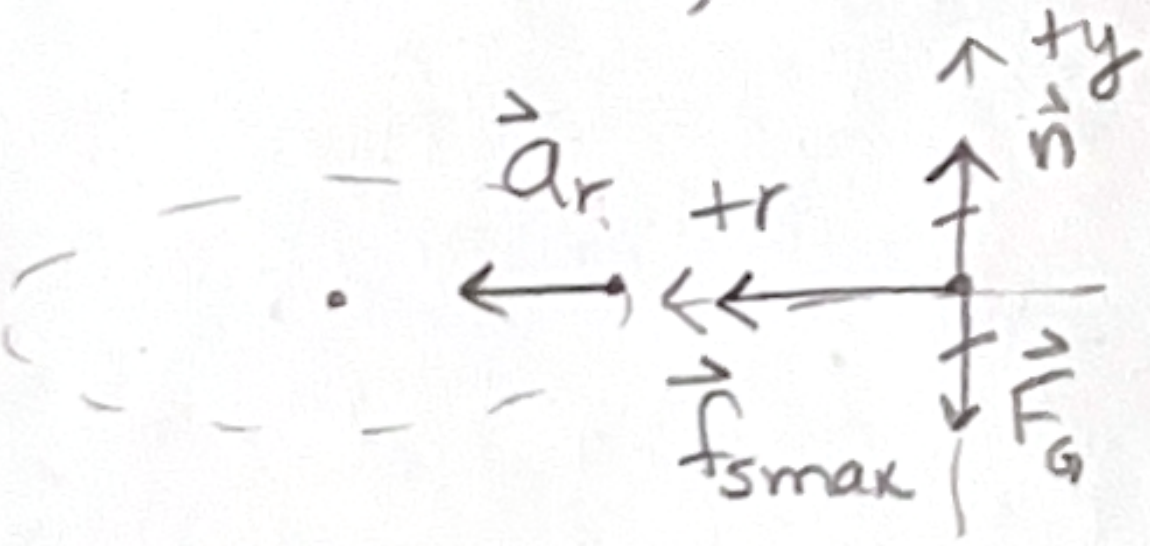
$\frac{V_t^2}{R} = \frac{+f_s}{m}$

$\boxed{f_s = \frac{mV_t^2}{R}} = \frac{(22\,kg)(2.5\,m/s)^2}{(1.8\,m)} = \boxed{76\,N}$

$\boxed{\text{toward the center of the curve}}$

b. What is the maximum speed at which the suitcase can complete the turn at this radius?

At V_{max}, friction is f_{smax}.



$\vec{F}$	F_r	F_y
$\vec{n}$	$n_r = 0$	$n_y = +n$
$\vec{F_G}$	$F_{Gr} = 0$	$F_{Gy} = -mg$
$\vec{f_{smax}}$	$f_{smax\,r} = +\mu_s n$	$F_{smax\,y} = 0$

Find V_{max}:

$a_r = \frac{\Sigma F_{on\,s\,r}}{m_s}$ $a_y = \frac{\Sigma F_{on\,s\,y}}{m_s}$

$\frac{V_{max}^2}{R} = \frac{\mu_s n}{m_s}$ $0 = +n + -mg$

$n = mg$

$V_{max}^2 = \frac{\mu_s n R}{m_s}$

$V_{max}^2 = \frac{\mu_s \cancel{m_s} g R}{\cancel{m_s}}$

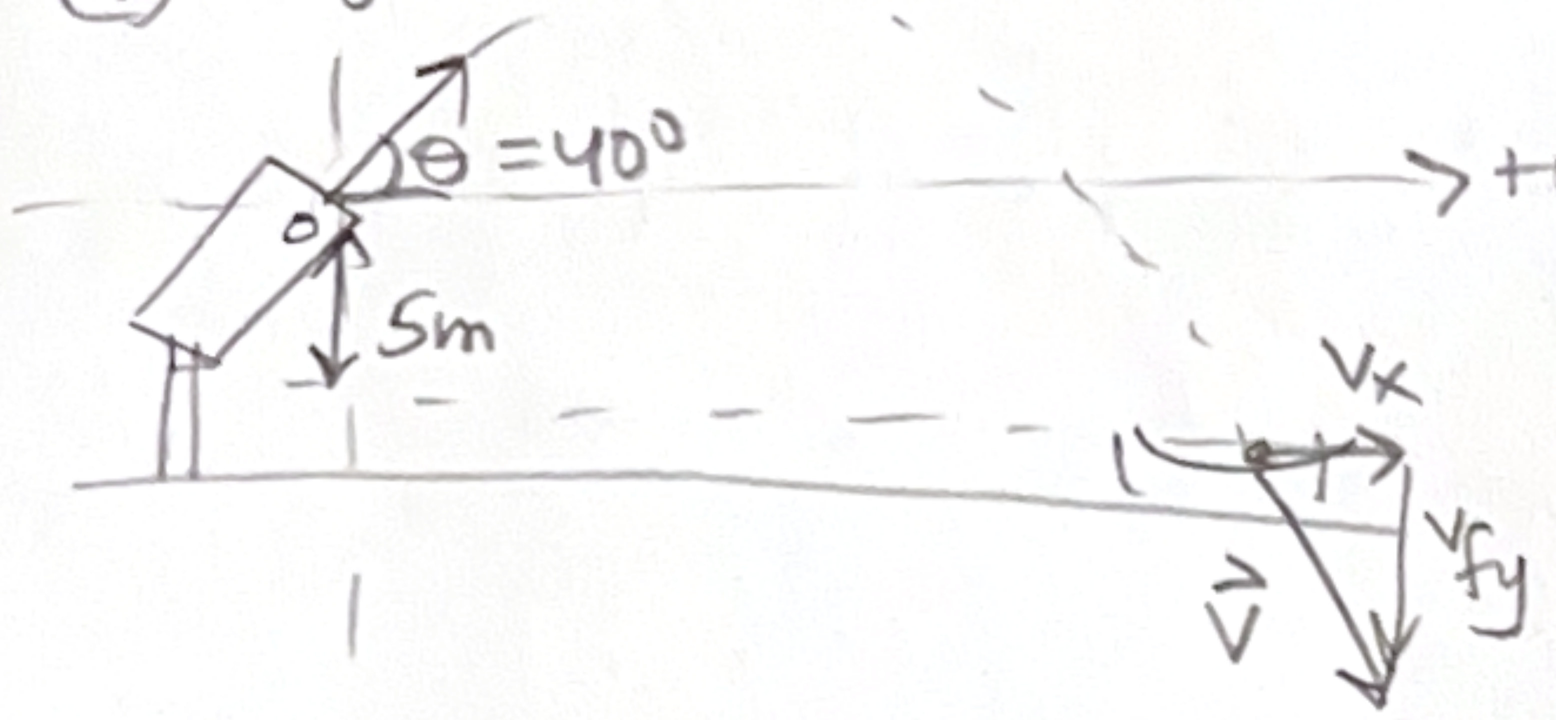
$\boxed{V_{max} = \sqrt{\mu_s g R}} = \sqrt{(.8)(10\,\frac{N}{kg})(1.8\,m)} = \boxed{3.8\,m/s}$

2. A human cannonball is launched from the cannon at an initial speed 27 m/s (60 mph) at an angle of 40° above the horizontal. The net is 5 m lower than the height of the mouth of the cannon.

a. With what velocity does the human cannonball impact the net?

+y

① $V_o = 27\,m/s$



② Components of V_o

$V_x = 20.7\,m/s$

$V_{oy} = 17.4\,m/s$

④ Find V_{fy}:

$V_{fy}^2 = V_{iy}^2 + 2a_y\Delta y$

$\boxed{V_{fy} = \sqrt{V_{iy}^2 + 2a_y\Delta y}}$

$V_{fy} = \sqrt{(17.4\,m/s)^2 + 2(-10\,\frac{m}{s^2})(-5m)}$

$V_{fy} = \pm 20\,m/s$

$V_{fy} = -20\,m/s$ But this is only the vertical component!

③ H

$\Delta X =$

$V_x = V_o \cos\theta = 20.7\,m/s$

$\Delta t =$

V

$\Delta y = -5m$

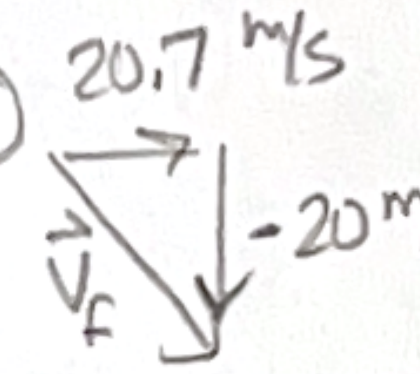
$V_{iy} = V_o \sin\theta = 17.4\,m/s$

$V_{fy} =$

$a_y = -10\,m/s^2$

$\Delta t =$

⑤



$V_f = \sqrt{(20.7\,m/s)^2 + (20\,m/s)^2} = 28\,m/s$

⑥ $\tan\theta = \frac{20\,m/s}{20.7\,m/s}$

$\theta = 44°$

His velocity is $(28\,m/s, -44°)$

b. At what horizontal distance from the mouth of the cannon should the net be placed?

Find Δx:

First Find Δt:

$V_{fy} = V_{iy} + a_y\Delta t$

$\boxed{\Delta t = \frac{V_{fy} - V_{iy}}{a_y}}$

$\Delta t = \frac{-20\,m/s - 17.4\,m/s}{-10\,m/s^2}$

$\Delta t = \boxed{3.74s}$

Now Find Δx:

$\Delta x = V_x \Delta t$

$\Delta x = (20.7\,m/s)(3.74s)$

$\Delta x = \boxed{77m}$ It should be placed 77m away from the launch point.