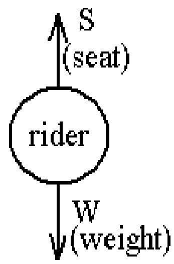
Phy 131 - Assignment 4

A.

a. Speed of rider: $\frac{distance}{time} = \frac{2\pi r}{.25\min} = \frac{2\pi(9m)}{15\sec} = 3.77m/s$

centripetal acceleration: $\frac{v^2}{r} = \frac{3.77^2}{9} = 1.58m/s^2$ ans.

b. Force at lowest point:



$\Sigma F = ma$

$S - W = m(v^2/r)$

$S - (40kg)(9.8m/s^2) = (40kg)(1.58m/s^2)$

(The acceleration is toward the center of the circle. Since the rider is directly beneath the center at this point, she is accelerating upward. So, a is positive.)

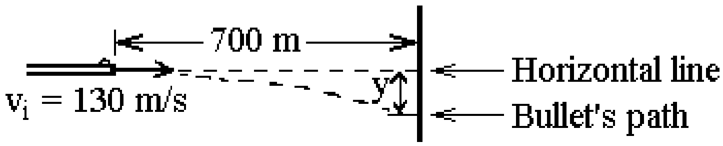
$S - 392 = 63$

S = 455 N ans.

(Notice that the centripetal force is not one individual force like gravity or the normal force from the seat. Rather, it's the net force on an object in circular motion which must equal $(mv^2)/r$.)

B. 1. The student is wrong in saying that its velocity is constant. Velocity is a vector, and its direction must be changing to follow a circular path.

2.



Find y.

x direction: Motion with a constant velocity: $x = (v_{x\,av})t$

The horizontal component of $\vec{v}$ remains equal to its initial value of 130 m/s.
The horizontal distance traveled is 700 m.

700 = 130 t

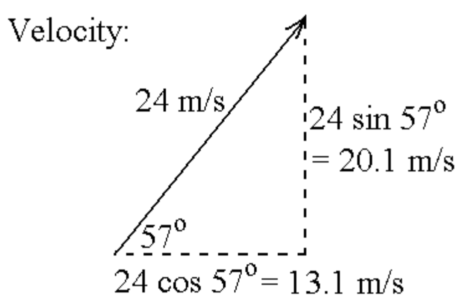
$t = \frac{700}{130} = 5.3846$ s

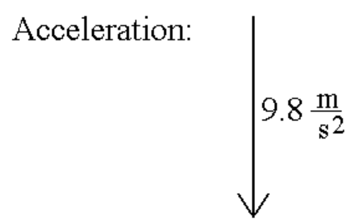
y direction: Motion with a constant acceleration: $y = v_{i\,y}t + ½\, a_y t^2$

The vertical component of $\vec{v}_i$ is 0 because it was moving horizontally.
Taking down as positive, $a_y = 9.8$ m/s^2.

$y = 0 + ½\,(9.8)(5.3846^2) =$ **142 m**

C. a.





So, v_x = 13.1 m/s , v_y = 20.1 m/s , a_x = 0 , a_y = –9.8 m/s^2

b. A projectile's horizontal velocity is constant. So if it started at 13.1 m/s, it will still be 13.1 m/s. Its vertical velocity behaves just like a ball thrown straight up; this would be zero at the maximum height. A freely falling object's acceleration is always the same thing regardless of its velocity, so a_x = 0 , v_y = –9.8 m/s^2

c.

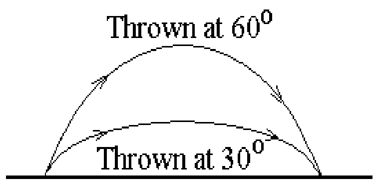
$$\Delta y = v_{iy} t + \frac{1}{2} a_y t^2$$
$$0 = (20.13)\,t + \frac{1}{2}(-9.8)t^2$$
Assuming $t \neq 0$, divide by t:
$$0 = 20.13 - 4.9\,t$$
$$4.9\,t = 20.13$$
$$t = 20.13/4.9 = 4.108 \qquad \boxed{4.11\,\text{s}}$$

d.

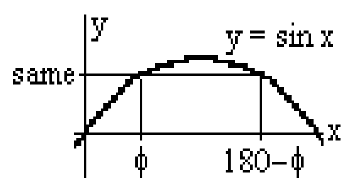
$$\Delta x = v_x t$$
$$= (13.07)(4.108)$$
$$= \boxed{53.7\ \text{m}}$$

(Or use $R = \dfrac{v_i^2 \sin(2\theta_i)}{g}$.)

D. 1. 60°.



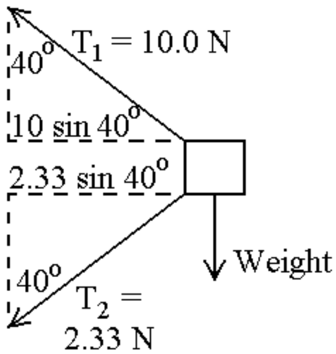
The range of a projectile is $R = (v_i^2 \sin 2\theta_i)/g$. v_i and g are the same. For any angle ϕ between 0 and 90°, sin ϕ = sin(180° – ϕ). In this particular case,



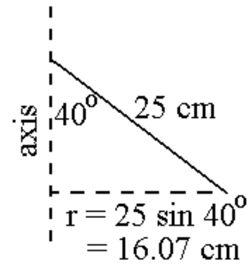
θ = 30°: sin[2(30°)] = sin 60° = .8660
θ = 60°: sin[2(60°)] = sin 120° = .8660

2.

Forces:



Distance from .6 kg to axis:



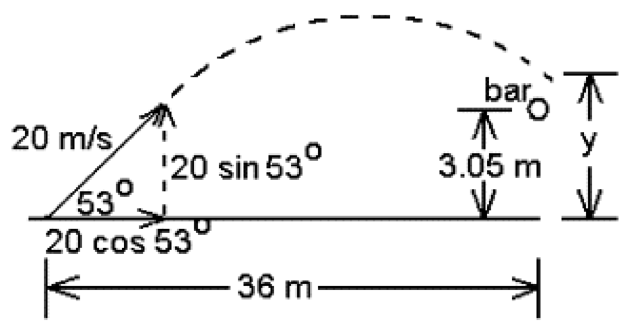
$$\Sigma F_x = ma \qquad \text{where } a = \frac{v^2}{r}$$

$$10 \sin 40^\circ + 2.33 \sin 40^\circ = (.6\ \text{kg})\frac{v^2}{.1607\ \text{m}} \qquad \text{(Left = positive.)}$$

$$6.428 + 1.498 = 3.734\ v^2$$

$$7.926 = 3.734\ v^2$$

$$v = \sqrt{\frac{7.926}{3.734}} = \boxed{1.46\ \text{m/s}}$$



E. a) $x = v_{ix}t$

$36 = (20 \cos 53°)t$

$t = 36 / (20 \cos 53°) = 2.99095$ s

$y = v_{iy}t + .5a_yt^2$

$y = (20 \sin 53°)(2.99095\text{ s}) + .5(-9.8)(2.99095^2) = 47.7736 - 43.8344 = 3.939$ m

So, it clears the bar by 3.939 – 3.05 = $\boxed{.889\text{ m.}}$

(If you rounded off more along the way, and got .9 m, that's close enough - I only take off credit for rounding if you miss the correct answer by 2%, and this is off by just 1.2%. Different numbers on a quiz could work out a little differently, so be careful.)

F. 1. Because both astronaut and ship are in free-fall, they have the same acceleration. Therefore, the ceiling doesn't catch up to the astronaut, and the astronaut doesn't catch up to the floor. (Note that the astronaut is not truly weightless; it's a common misconception that there is no gravity in space.)

2. The centripetal force is provided by friction between the coin and record.

Therefore, $f = \frac{mv^2}{r}$ where f is the friction force.

When the coin reaches 50 cm/s, it is right on the verge of slipping, so at this point $f = \mu_s n$.

$$\mu_s (\cancel{m}g) = \left(\frac{\cancel{m}v^2}{r}\right)$$

$$\mu_s = \frac{v^2}{gr} = \frac{(.50\,m/s)^2}{(9.8\,m/s^2)(.30\,m)}$$

$$= \boxed{.085} \text{ ANS}$$