PHY1321 PHY1331 Fall 2019 Assignment 7. Due Nov 1 , 6:00PM

LAST NAME: ____________________ ASSIGNED CLASS NUMBER______________

2-D Kinematics, Forces

1 The artillery gun with the muzzle velocity of 400ms is used to create an avalanche on the slope of the skiing mountain. The target is 13.0 km away horizontally, and 3.0km above the position of the gun.
a) What should be θ (the projectile angle above the horizontal) to reach the target?
b) What will be the magnitude and the direction (with respect to the horizontal plane) of the projectile when it hits the target.

$y = tan\theta x - \frac{g}{2v^2cos^2\theta}x^2$ when we put in the data we have: $3000 = tan\theta(13000) - \frac{9.8}{2(400^2)cos^2\theta}(13000)^2$
$0 = -3000 + (13000)tan\theta - 5175.625(tan^2\theta+1)$ leading to $0 = 8175.625 - (13000)tan\theta + 5175.625(tan^2\theta)$

$$Since\ in\ this\ case: b^2 - 4ac = -255876.5625 < 0$$

The problems has no solutions. This gun will never hit the target specified on the problem

2 At what angle the artillery gun has to be pointed so that the maximum height of projectile is equal to the half of its range?

$y = tan\theta x - \frac{g}{2v^2cos^2\theta}x^2 \Rightarrow \frac{R}{2} = tan\theta\frac{R}{2} - \frac{g}{2v^2cos^2\theta}(\frac{R}{2})^2 \Rightarrow \frac{1}{2} = \frac{1}{2}tan\theta - \frac{1}{4}\frac{g}{2v^2cos^2\theta}R \Rightarrow$

$\frac{1}{2} = \frac{1}{2}tan\theta - \frac{1}{4}\frac{g}{2v^2cos^2\theta}\left(\frac{v^2sin2\theta}{g}\right) \Rightarrow \frac{1}{2} = \frac{1}{2}tan\theta - \frac{1}{4}\frac{sin2\theta}{2cos^2\theta} \Rightarrow \frac{1}{2} = \frac{1}{2}tan\theta - \frac{1}{4}\frac{2cos\theta sin\theta}{2cos^2\theta} \Rightarrow$

$\frac{1}{2} = \frac{1}{2}tan\theta - \frac{1}{4}tan\theta \Rightarrow \frac{1}{2} = \frac{1}{4}tan\theta \Rightarrow \theta = 63.43$ (ANS)

3 A race car starts from rest on a circular track. The car increases its speed at a constant rate a_t as it goes once around the track. Find the angle that the total acceleration of the car makes- with the radius connecting the center of the track and the car- at the moment the car completes the circle.
SOLUTION:
From kinematic equations final(after one full turn) v may be found from: $v^2 - 0 = 2a_t(2\pi r)$
and so radial acceleration at this moment will be: $a_r = \frac{v^2}{r} = \frac{4a_t\pi r}{r} = 4\pi a_t$
Finally: $tan\theta = \frac{a_t}{a_r} = \frac{a_t}{4\pi a_t} = \frac{1}{4\pi}$ and $\underline{\theta = 4.55°}$

4 Draw clear Free Body Diagrams (FBD) for each of the following cases, determine whether object is in equilibrium or not and write the proper scalar equations for relevant force components.

a) object of mass M on the frictionless incline ($\alpha = 20°$).
b) object of mass m suspended on the single rope from the ceiling of the elevator accelerating up with acceleration a.
c) object mass m moving with constant speed on the rough horizontal surface pushed by the F_{app} at 20° below horizontal.
d) object of mass M is in equilibrium while suspended from a massless knot attached to the two cords making the angles of 30° and 45° with horizontal ceiling.

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5 An automobile is moving at speed of 2.00 m/s along a circular road of radius 20 m.
A) Find the time it takes to make one full circle when the car is still moving at constant speed. (1P)
B) Find the car radial acceleration during this time. (1P)
Then its speed starts increasing at a rate of 0.600 m/s^2 while it stays on the same road.
C)How long would it take for the car to make one full turn from the moment it started its tangential acceleration?

$v = \frac{(2\pi r)}{\Delta t} \Rightarrow \Delta t = \frac{(2\pi r)}{v} = 20\pi \frac{m}{s}$ (ANS A) $a_r = \frac{v^2}{r} = \frac{2^2}{20} = \frac{1}{5}\frac{m}{s^2}$ (ANS B)

${v_f}^2 - {v_i}^2 = 2a_t(2\pi r) = 48\pi \frac{m^2}{s^2}$ $v_f = \sqrt{50\pi}\frac{m}{s}$

$v_f = v_i + a_t\,\Delta t$ $\Delta t = \frac{v_f - v_i}{a_t} = 17.55s$ (ANSC)

6 A dive bomber has a velocity of 300 m/s at an angle θ below the horizontal. When the altitude of the aircraft is 2.5 km, it releases a bomb, which subsequently hits a target on the ground. The magnitude of the displacement from the point of release of the bomb to the target is 4.0 km. Find the angle θ .

Let's assign the positive y direction to be upwards and the horizontal direction along which the plane is moving as positive x direction.

Let's bomber initial position (when it releases the bomb) be (0,0).

The final position is $y = -2500m \;\; x = 4000^2 - 2500^2 = 3122m$

We may use the trajectory equation y(x) obtained in class (from the fundamental equations describing the projectile (x(t) and y(t)): $y = (tan\theta)x - \frac{g}{2(vcos\theta)^2}x^2$. This leads to 2500$= (tan\theta)3122 - \frac{g}{2(300cos\theta)^2}3122^2$

$$0 = 2500 + (tan\theta)3122 - \frac{9.8 \cdot 3122^2}{2(300)^2}(1 + (tan\theta)^2)$$

$$0 = \left\{2500 - \frac{9.8 \cdot 3122^2}{2(300)^2}\right\} + 3122(tan\theta) - \frac{9.8 \cdot 3122^2}{2(300)^2}((tan\theta)^2)$$

$$0 = \left\{2500 - \frac{9.8 \cdot 3122^2}{2(300)^2}\right\} + 3122(tan\theta) - \frac{9.8 \cdot 3122^2}{2(300)^2}((tan\theta)^2)$$

Solving this quadratic equation leads to the following solutions: $tan\theta$ = 6.458 or $tan\theta$=-0.57466

The first solution is leads to a positive angle θ which in the context of this problem does not make sense.(bomb is released while the plane is moving at the angle below horizontal!

The second answer results <u>in $\theta = -29.88°$</u>

7 Draw Free Body Diagrams (FBD) and write down the corresponding equations for the two cartesian components in each of the following cases:

a) an object of Mass M is hanging from a massless knot attached to two strings making angles of 30^o and 63^o with celling of the accelerating elevator.

b) an object of Mass M on the frictionless incline (alpha=30) accelerated up by by the force F_{app} applied at the end of massless cord (angle 70 with the horizontal.)