Assignment 7:
KINEMATICS 2-D Motion

UNIVERSITY OF OTTAWA
Principles of Physics
PHY1321/1331 FALL 2018
Dr. A. Czajkowski

Assigned: Oct 31
Due: Nov 5 6:00PM

1

A river boat takes 4hrs when going with the current from point A to point B (along the straight river), while its engine is using maximum power (the boat is at full speed). It takes 10 hrs. for the boat to go back (against the current) at full speed. How long will it take for the same boat to make the trip down the river again with its engine off?

Trip 1: $v_r + v_B = \frac{D}{4hr}$ Trip 2: $v_B - v_r = \frac{D}{10hr}$

Subtracting above equations side by side : $2v_r = \frac{D}{4hr} - \frac{D}{10hr}$ so: $v_r = \frac{1}{2}\left(\frac{D}{4hr} - \frac{D}{10hr}\right) = \frac{1}{2}\left(\frac{5D}{20hr} - \frac{2D}{20hr}\right) = \left(\frac{3D}{40hr}\right)$

$v_r = \left(\frac{D}{\frac{40}{3}hr}\right)$ ANSWER: It takes 13hrs and 20 minutes to travel the distance AB driven by the current alone.

2. A tire 0.600 m in radius rotates at a constant rate of 300 rev/min. Find the speed and acceleration of a small stone lodged in the tread of the tire (on its outer edge).

$$v_t = \frac{2\pi r}{T} = \frac{2\pi(0.500\text{ m})}{\frac{60.0\text{ s}}{200\text{ rev}}} = 10.47\text{ m/s} = \boxed{10.5\text{ m/s}}$$

$$a = \frac{v^2}{R} = \frac{(10.47)^2}{0.5} = \boxed{219\text{ m/s}^2\text{ inward}}$$

3 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.

~~When the bomb has fallen a vertical distance 2.15 km, it has traveled a horizontal distance given by~~

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 in $\theta = -29.88°$

4 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)

C) Then its speed starts increasing at a rate of 0.600 m/s^2 while it stays on the same road. ~~When the instantaneous speed of the automobile is 4.00 m/s~~, how long would it take for the car to make one full turn from the moment it started its tangential acceleration? (2p)

PLEASE NOT THAT DUE TO TYPO IN THE LAST PART EVERYBODY GETS FULL MARKS FOR PART (C)

PROVIDE THE SOLUTION ON THE OPPOSITE PAGE

Assignment 7: CONT.

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STUDENT #: ________________

NAME: ______________________

5 For each of the equilibrium cases below, draw a small FBD, write the proper form of Newton Equation for each of the force's component. Also write down the reading of the fish-scale in each case

A) Ta=49N

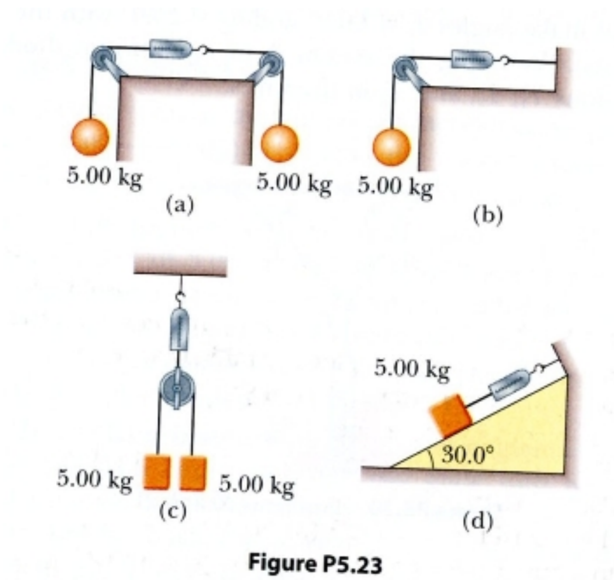


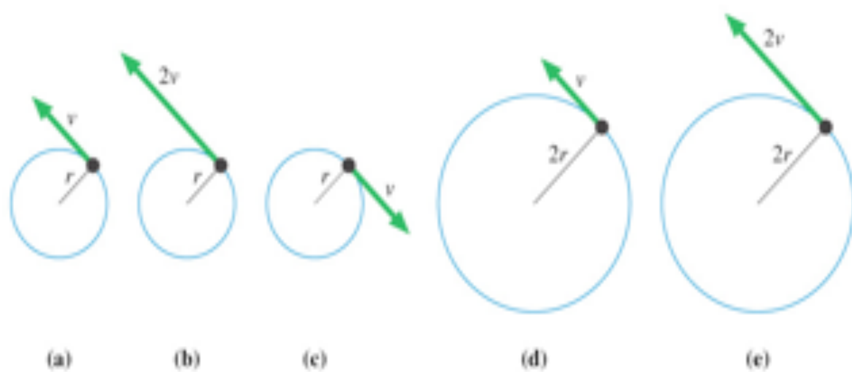
Figure P5.23

B) Tb =49

C)Tc=49N

D) Td=24.5N

6 In each case below same mass m is spinning on the piece of string.



Rank in order, from largest to smallest, the magnitude of the Tensions (Ta) to (Te) of particles a to e.

ANSWER: $T_b > T_e > T_a = T_c > T_d$

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

PROVIDE THE SOLUTION ON THE OPPOSITE PAGE

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

Using this for the parabola vertex (R/2, 2R) we get: $2R = (tan\theta)\frac{R}{2} - \frac{g}{2(vcos\theta)^2}\left(\frac{R}{2}\right)^2$ *which leads to*

$2 = \frac{(tan\theta)}{2} - \frac{g}{2(vcos\theta)^2}\frac{R}{4}$.

By substituting the expression for Range R=$\frac{v^2 sin2\theta}{g}$ we obtain:

$2 = \frac{(tan\theta)}{2} - \frac{g}{8(vcos\theta)^2}\frac{v^2 sin2\theta}{g}$ which simplifies to

$2 = \frac{(tan\theta)}{2} - \frac{1}{8cos^2\theta}\frac{2cos\theta sin\theta}{1}$ and

$2 = \frac{(tan\theta)}{2} - \frac{sin\theta}{4cos\theta}$

to finally yield $2 = \frac{tan\theta}{2} - \frac{tan\theta}{4}$.

We conclude with $8 = tan\theta$ giving $\theta = 82.9°$

ANSWER: To reach the maximum height of twice its range the projectile has to be shot at 83 degrees.

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)
C) Then its speed starts increasing at a rate of 0.600 m/s^2 while it stays on the same road.

~~When the instantaneous speed of the automobile is 4.00 m/s~~, how long would it take for the car to make one full turn from the moment it started its tangential acceleration?

$$v = \frac{2\pi R}{T} \Longrightarrow T = \frac{2\pi R}{v} = \frac{\pi\,40}{2} = 62.83s$$

$$a = \frac{v^2}{R} = \frac{4}{20}\frac{m}{s^2} = \frac{1}{5}\frac{m}{s^2}$$

$$2\pi r = vt + \frac{1}{2}a_t t^2$$

$$0 = -40\pi + 2t + \frac{1}{2}0.6t^2$$

t_1=-24.0s t_2= 17.4s