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

LAST NAME: ______________________ ASSIGNED CLASS NUMBER_______________

1 The height of a Harrier airplane above the ground is given by $h = 4.00t^3$, where h is in meters and t is in seconds. After 3.00 s, the airplane releases a small mailbag. How long after its release does the mailbag reach the ground?

SOLUTION: $y = 4t^3$: At $t = 3s$, $y_i = 4(3^3) = 108m$ and since $v_y = \frac{dy}{dt} = 12t^2$ $v_y(3s) = 108\frac{m}{s}$ ↑

If the helicopter releases a small mailbag at this time, the equation of motion of the mailbag is

$$y_f = y_i + v_y t - \frac{1}{2}gt^2 = 108 + 108t - 4.9t^2$$

Setting final position at 0 when bag lands on the ground we solve for t,

$$0 = 108 + 108t - 4.9t^2.$$

Solving for t, (only positive values of t count), t=22.999s=23s

2 A rock is dropped from rest into a well. (a) The sound of the splash is heard 2.40 s after the rock is released from rest. How far below the top of the well is the surface of the water? The speed of sound in air (at the ambient temperature) is 336 m/s. (b) **What If?** If the travel time for the sound is neglected, what percentage error is introduced when the depth of the well is calculated?

(a) $d = \frac{1}{2}(9.80)t_1^2$ $\qquad d = 336t_2$

$t_1 + t_2 = 2.40$ $\qquad 336t_2 = 4.90(2.40 - t_2)^2$

$4.90t_2^2 - 359.5t_2 + 28.22 = 0$ $\qquad t_2 = \frac{359.5 \pm \sqrt{359.5^2 - 4(4.90)(28.22)}}{9.80}$

$t_2 = \frac{359.5 \pm 358.75}{9.80} = 0.0765\text{ s}$ so $d = 336t_2 = \boxed{26.4\text{ m}}$

(b) Ignoring the sound travel time, $d = \frac{1}{2}(9.80)(2.40)^2 = 28.2\text{ m}$, an error of. $\boxed{6.82\%}$

3 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 8 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: $v_r + v_B = \frac{D}{4hr}$ $\qquad$ Trip 2: $v_B - v_r = \frac{D}{8hr}$

Subtracting above equations side by side : $2v_r = \frac{D}{4hr} - \frac{D}{10hr}$ so:

$v_r = \frac{1}{2}\left(\frac{D}{4hr} - \frac{D}{8hr}\right) = \frac{1}{2}\left(\frac{2D}{8hr} - \frac{D}{8hr}\right) = \left(\frac{D}{16hr}\right)$ $\qquad v_r = \left(\frac{D}{16hr}\right)$

ANSWER: It takes 16hrs to travel the distance if the boat is driven by the current alone.

4 Two railroad tracks intersect at right angles at station O. At 11AM the train A, moving west with constant speed of 50 km/h, leaves the station O. One hour later train B, moving south with the constant speed of 60 km/h, passes through the station O. Find minimum distance between these trains.

SOLUTION: BELOW FOR v_A=50km/h and v_B=60km/h

Train A moves along z axis and at time t it will have position: $x_A = V_A t = 50t$. Train B moves along the y axis and at time t it will have position: $y_B = 60 - V_B t = 60 - 60t$. The distance between the two trains is given by: $D = \sqrt{x_A^2 + y_B^2} = \sqrt{(50t)^2 + (60 - 60t)^2}$ The minimum distance is given by the condition:

$$\frac{dD}{dt} = 0 \Rightarrow \frac{1}{2}\frac{1}{\sqrt{2500t^2 + (60-60t)^2}} \times [2(2500t) + 2(60-60t)(-60)] = 0$$

$$(2500t) + (60-60t)(-60) = 0 \Rightarrow (2500+3600)t = 3600 \Rightarrow t = \frac{3600}{6100} = \frac{36}{61}(hr) = 35.41\text{min} = 35\text{min}\,24.6\text{sec}$$

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5 a) A body covers 36% of the total distance fallen in the last second. From what height did it fall?

$\frac{1}{2}gt^2 = d$ also $\frac{1}{2}g(t-1)^2 = 0.64d$

$\frac{(t-1)^2}{t^2} = 0.64$ so: $\frac{t-1}{t} = 0.8$ which leads to $0.2t = 1$t=5s and d=122.5m

b) The maximum height from which a person can safely jump is 2.56 m.
What is the maximum allowable landing speed for a parachutist

$v^2 = 2gd = 2(9.8)(2.56)176m$ ANS v = 7.08m/s

6 Cheetah can reach 108km/h in 2 s and it can maintain this speed for 15 s. After this time it must rest. An antelope can reach 88.2km/h in 2 s and can sustain it for a very long time. Suppose the two animals are initially separated by 80m and the antelope reacts in 0.5s.

a) can cheetah get the antelope?

b) if not, how close does it get?

Assume both start from the rest and accelerate uniformly to their maximum speeds.

SOLUTION:

Due to the fact that both animals change their type of motion during the 17seconds in question, there is no single equation that can be written describing this situation.

First 2.5 seconds cheetah accelerates for 2 seconds and runs at max speed for 0.5 seconds while antelope rests for 0.5 seconds and then accelerates for 2 seconds.

To solve this problem one might calculate how far are they at 2.5 seconds.

Cheetah maximum speed $v_{ch} = 30\frac{m}{s}$ cheetah acceleration: $a_{ch} = 15\frac{m}{s^2}$

Antelope maximum speed $v_{an} = 24.5\frac{m}{s}$ antelope acceleration: $a_{an} = 12.25\frac{m}{s^2}$

Cheetah covers distance $\frac{1}{2}at^2$ =30m (during the acceleration) and additional15 m, during 0.5 seconds.

Antelope covers distance $\frac{1}{2}at^2$ =24.5m during the acceleration.

At the end of first 2.5 seconds from the moment cheetah starts its hunt the two animals are 59.5 meters apart.

$y_{ch} = v_{ch}t = 30\frac{m}{s}14.5s = 435m$ $y_a = 59.5m + v_{an}t = 24.5\frac{m}{s}14.5s = 414.75m$

Since distance covered in 14.5s by cheetah is longer than that covered by the antelope, cheetah will kill antelope. It will happened before the chase is over at time given by:

$30\frac{m}{s}t$=$59.5m + 24.5t$ $\underline{t = 10.81s}$