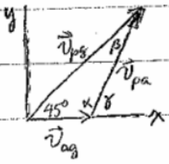
PHY 1124 Test #1 solutions (see questions at end) 2013

1. (e)

2. (c) Method (i) $v_{pg,x} = v_{ag} + v_{pa}\cos\gamma$; $v_{pg,y} = v_{pa}\sin\gamma$ with $v_{pg,x} = v_{pg,y}$ gives

$v_{ag}/v_{pa} + \cos\gamma = \sin\gamma$ which is satisfied by $\gamma \cong 49°$ for $\frac{v_{ag}}{v_{pa}} = \frac{32\,m/s}{320\,m/s} = \frac{1}{10}$

$\therefore 90-49 = 41°$ E of N.



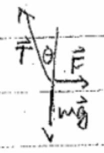
Method (ii) $\frac{\sin 45°}{v_{pa}} = \frac{\sin\beta}{v_{ag}} \Rightarrow \sin\beta = \frac{v_{ag}}{v_{pa}}\sin 45° = \frac{32}{320}\frac{1}{\sqrt{2}} = 0.0707 \quad \therefore \beta = \sin^{-1} .0707 = 4.05°$

$\alpha = 180 - 45 - 4.05 = 130.95° \cong 131° \Rightarrow 131 - 90 = 41°$ E of N.

3. (b) $y = y_0 + v_{oy}t - \frac{1}{2}gt^2 \Rightarrow v_{oy}t = y - y_0 + \frac{1}{2}gt^2$

$v_{oy} = \frac{y-y_0}{t} + \frac{1}{2}gt = \frac{6.0\,m}{0.4\,s} + \frac{1}{2}(9.8\,\frac{m}{s^2})(0.4\,s) = 15 + 1.96 = 17\ m/s$

4. (c)



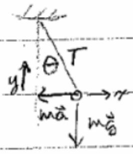
$0 = ma_x = -T\sin\theta + F \Rightarrow T = F/\sin\theta = 1/\sin\theta$ N

$0 = ma_y = T\cos\theta - mg \Rightarrow T = mg/\cos\theta = 3/\cos\theta$ N

$T = (T_x^2 + T_y^2)^{1/2} = (1^2 + 3^2)^{1/2} = \sqrt{10}$ N (aside $\theta = \tan^{-1}\frac{1}{3} = 18.4°$)

5. (a)

6. (b)

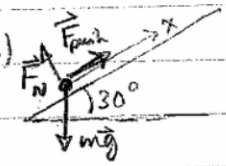


$m(-\frac{v^2}{r}) = ma_x = T\sin\theta \qquad 0 = ma_y = T\cos\theta - mg$

$\therefore \tan\theta = \frac{T\sin\theta}{T\cos\theta} = \frac{\frac{mv^2}{r}}{mg} = \frac{v^2}{rg} = \frac{(15\,m/s)^2}{(200\,m)(9.8\,m/s^2)} = 0.115$

$\therefore \theta = \tan^{-1} .115 = 6.5°$

7. (e)



$ma_x = -mg\sin 30° + F_{push}$

$\therefore F_{push} = ma_x + mg\sin 30° = mg\left(\frac{a_x}{g} + \sin 30°\right) = 80\underbrace{\left(\frac{1.5}{9.8} + \frac{1}{2}\right)}_{.653} = 52.2\,N$

$W = F_{push}d = 52.2 \times 50 = 261$ J.

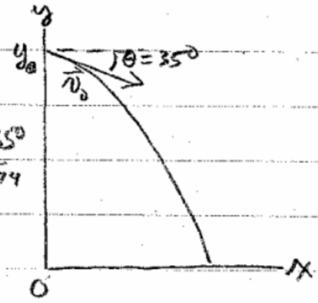
8. (d) $a_x = \frac{F_{net,x}}{m_{total}} = \frac{36N}{4+20\,kg} = 1.5\ \frac{m}{s^2}$

$F_{onY} = m_Y a_x = (20)(1.5) = 30$ N

9. $y = y_0 + v_{0y} t - \frac{1}{2} g t^2$ where $v_{0y} = -v_0 \sin\theta$

when hits ground $y=0$ $= -(200\frac{m}{s})\underbrace{\sin 35°}_{0.574}$

$0 = y_0 + v_{0y} t - \frac{1}{2} g t^2$ $= -114.7\frac{m}{s}$



$\therefore t = \frac{1}{2(-\frac{1}{2}g)}\left(-v_{0y} \pm \sqrt{v_{0y}^2 - 4(-\frac{1}{2}g)y_0}\right)$

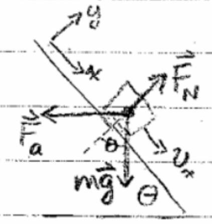
$= \frac{1}{g}\left(v_{0y} \pm \sqrt{v_{0y}^2 + 2gy_0}\right)$ ← need + sign but $t>0$ since $v_{0y}<0$.

$= \left(\frac{1}{9.8\frac{m}{s^2}}\right)\left(-114.7\frac{m}{s} + \sqrt{(114.7\frac{m}{s})^2 + 2(9.8\frac{m}{s^2})(500\,m)}\right) = 3.76\,s$

$x = v_{0x} t = v_0(\cos\theta)t = (200\,m/s)\underbrace{(\cos 35°)}_{0.819}(3.76\,s) \cong 616\,m$

10. $0 = F_{net,y} = F_N - mg\cos\theta - F_a \sin\theta$ where $F_a = |\vec{F}_a|$

$\Rightarrow F_N = mg\cos\theta + F_a \sin\theta$



$m a_x = F_{net,x} = mg\sin\theta - F_a\cos\theta - \mu F_N$

$= mg\sin\theta - F_a\cos\theta - \mu mg\cos\theta - \mu F_a \sin\theta$

$\therefore F_a(\cos\theta + \mu\sin\theta) = mg(\sin\theta - \mu\cos\theta) - m\underbrace{a_x}_{-g/7}$

$F_a = mg\,\frac{\sin\theta - \mu\cos\theta + \frac{1}{7}}{\cos\theta + \mu\sin\theta}$

(This is magnitude of $\vec{F}_a$ if it points to left as given, which is the case for $\sin\theta - \mu\cos\theta + \frac{1}{7} > 0$.)

PART A: ANSWERS TO ALL MULTIPLE CHOICE QUESTIONS MUST BE INDICATED HERE

1. A graph of the motion of an object (moving in 1-dimension, starting from time $t = 0$) is plotted with the displacement on the vertical axis and the time on the horizontal axis. The graph is a straight line. Which of these quantities CANNOT be determined from this graph?
   a. the displacement from $t = 0$ b. the initial velocity at $t = 0$
   c. the acceleration of the object d. the average velocity of the object
   e. All four of the quantities can be determined from the graph.

2. A pilot wants to fly an airplane to a destination that is in a direction 45° east of north, with respect to his starting point. The wind is blowing from 270° at 32 km/h, and the speed of the airplane through the air is 320 km/h. The pilot should maintain a heading of approximately
   a. 15° b. 49° c. 41° d. 4° e. 131°

3. You throw a ball directly upwards in the air. It first passes a tree branch located 6 m above you at a time 0.4 s later. The initial speed with which you released the ball is:
   a. 19 m/s b. 17 m/s c. 15 m/s d. 13 m/s e. 11 m/s

4. A pendulum bob with a weight of 3 N is held at an angle θ from the vertical by a horizontal force $\vec{F}$ of magnitude 1 N as shown. The tension in the string supporting the pendulum bob (in newtons) is:
   a. $3\cos\theta$
   b. $1/\cos\theta$
   c. $\sqrt{10}$
   d. 3
   e. none of these

5. In a tug-of-war, two men pull on opposite ends of a rope, each with a force of 300 N, in opposite directions. The tension in the rope is (in N)

   a. 300 b. 600 c. zero d. 150 e. 424

6. A car is moving horizontally at a constant speed of 15 m/s around a curve which is in the shape of a circle with radius 200 m. A pendulum hangs freely inside the car. What is the angle of the pendulum with respect to the vertical?

   a. $0.4°$ b. $6.5°$ c. $48°$ d. $63°$ e. $83°$

7. A man pushes a crate (of weight 80 N) a distance of 5.0 m upward along a frictionless slope that makes an angle of $30°$ with the horizontal. The constant force he exerts is parallel to the slope. If the speed of the crate increases at a rate of 1.5 m/s^2, then the work done by the man is:

   a. −200 J b. 61 J c. 140 J d. 200 J e. 260 J

8. Two blocks (X and Y) are in contact on a horizontal, frictionless surface. A constant force of magnitude 36 N is applied to X as shown. The force exerted by X on Y is:

   a. 1.5 N b. 6.0 N
   c. 29 N d. 30 N
   e. 36 N

PART B: ANSWER IN THE SPACE PROVIDED, SHOWING ALL YOUR WORK

9. A rescue airplane is diving at an angle of 35° below the horizontal with a speed of 200 m/s. It releases a survival package when it is at an altitude of 500 m. Find the horizontal distance of the point of impact, from the plane at the moment of the package's release. (Ignore air resistance.)

10. A block of mass m is sliding down an inclined plane as shown. The coefficient of kinetic friction of the plane on the block is μ. A person is exerting a horizontal force $\vec{F_a}$ in the direction shown, so that the block is slowing down with an acceleration of magnitude $|\vec{a}| = g/7$, where g is the acceleration due to gravity. Using the coordinate system shown, derive an expression for the magnitude of the force $\vec{F_a}$, in terms of the variables θ, m, μ, and g.