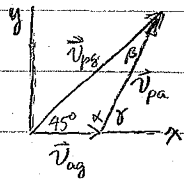
PHY 1124 Test #1 solutions (see questions at end) 2013

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 $\gamma \cong 41°$ for $\frac{v_{ag}}{v_{pa}} = \frac{32\ m/s}{320\ m/s} = \frac{1}{10}$



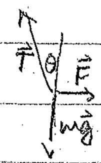

Method (ii) $\frac{\sin 45°}{v_{pa}} = \frac{\sin\beta}{v_{ag}} \Rightarrow \sin\beta = \frac{v_{ag}}{v_{pa}}\sin 45° = \frac{32}{320}\frac{1}{\sqrt{2}} = 0.0707$ ∴ $\beta = \sin^{-1} .0707 = 4.05°$

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

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

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

4. (c)



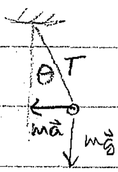

$0 = ma_x = -T\sin\theta + F \Rightarrow T = F/\sin\theta = 1/\sin\theta$ N

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

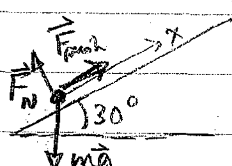



$m(-\frac{v^2}{r}) = ma_x = T\sin\theta$ $0 = ma_y = T\cos\theta - mg$

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

∴ $\theta = \tan^{-1} .115 = 6.5°$

7. (e)




$ma_x = -mg\sin 30° + F_{push}$

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

$W = F_{push}\,d = 52.2 \times 50 = 2610$ J.

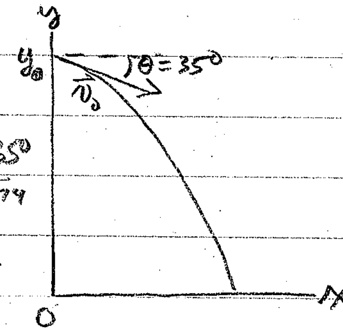
8. (d) $a_x = \frac{F_{net,x}}{m_{total}} = \frac{36\,N}{4 + 20\,kg} = 1.5\ \frac{m}{s^2}$

$F_{on\,Y} = m_Y a_x = (20)(1.5) = 30$ N

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

when hits ground $y=0$ $\quad = -(200\,\tfrac{m}{s})\sin 35^\circ$ ($\sin 35^\circ$ = 0.574)

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




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

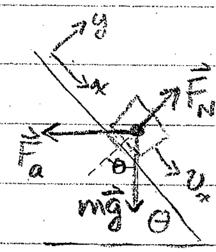
$$= \frac{1}{g}\left(v_{0y} \pm \sqrt{v_{0y}^2 + 2 g y_0}\right)$$ ← need + sign for $t>0$ since $v_{0y}<0$.

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

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

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

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




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

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

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

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

(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

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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 $\theta$ 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 $1.5\ \text{m/s}^2$, 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