1. (1 pt) In the absence of air resistance, a ball of mass $m$ is tossed upward to reach a height of 20 meters. At the 10 meter position, the net force on the ball is:
   a. $2mg$  
   b. $mg$  
   c. $mg/2$  
   d. $mg/4$  

2. (1 pt) Vector $A$ is added to vector $B$. Under what conditions does the resultant vector $A + B$ have greatest magnitude?
   a. When $A$ and $B$ are parallel and in the same direction.  
   b. When $A$ and $B$ are parallel and in the opposite direction.  
   c. When $A$ and $B$ are perpendicular.  
   d. The magnitude of $A + B$ does not depend on the directions of $A$ and $B$.  

3. (1 pt) A math book and a physics book are tied together with a length of string. With the string taut, one book is pushed off the edge of a table. As it falls, the other book is dragged horizontally across the table surface. With no friction, the acceleration of the books is:
   a. zero  
   b. $g$  
   c. between 0 and $g$  
   d. greater than $g$  

4. (1 pt) You slam on your brakes in a panic and skid a certain distance down a straight and level road. If you had been travelling twice as fast, what distance would the car have skidded under the same conditions?
   a. Four times further  
   b. Two times further  
   c. $\sqrt{2}$ times further  
   d. It is impossible to tell  

5. (8 pts) A student throws a tennis ball straight up from a height of 6 ft. The ball reaches a maximum height of 25 ft. Determine the time it takes for the ball to hit the ground.

   \[ 2.33 \text{ sec} \]

   \[ \frac{v_i}{0} - 3 \]

   \[ 1 - 2 \quad s_2 = s_1 + \frac{v_i^2 - v_f^2}{2a} \]
   \[ 25 = 6 + \frac{0 - (3.4)^2}{2(-32.2)} \]

   \[ 1 - 3 \quad s_3 = s_1 + v_1t + \frac{1}{2}at^2 \]
   \[ 0 = 6 + 34.98t + \frac{1}{2}(-32.2)t^2 \]
   \[ t \approx 2.33 \text{ sec} \]

6. (8 pts) Three reindeer compete in a 6 mile reindeer relay race. Each runs 2 miles. Dasher runs his part in 10 minutes, Prancer runs his part at 7 mph. Comet starts strong at 12 mph, but slows down at a constant rate finishing at 8 mph. Determine the team’s total time for the race.

   \[ \sqrt{39.1 \text{ min}} \quad \text{or} \quad 0.652 \text{ hr} \quad \text{or} \quad 2346 \text{ sec} \]

   | Part |  |  |  |
---|---|---|---|
1. |  |  |  |
   | \[ t = 10 \text{ min} \]  
2. |  |  |  |
   | \[ t = \frac{d}{V} = \frac{2 \text{ mi}}{7 \text{ mi/hr}} = 17.1 \text{ min} \quad 0.285 \text{ hr} \]  
3. |  |  |  |
   | \[ d = 2 \text{ mi}; v_1 = 12 \text{ mph}; v_2 = 8 \text{ mph}; s_2 = s_1 + \frac{v_1 + v_2}{2} t \]  
   | \[ t = \frac{2d}{v_1 + v_2} = \frac{2(2)}{12 + 8} = 0.2 \text{ hr} \quad \frac{60 \text{ min}}{hr} = 12 \text{ min} \]  
   | \[ t_{\text{tot}} = 10 + 17.1 + 12 = 39.1 \text{ min} \]
7. (8 pts) Rudolph flies 25 miles at 30° W of N. He then flies 40 miles at 18° N of E. How far and in what direction must he fly to return to his starting point?

\[ d = \sqrt{25^2 + 40^2 - 2(25)(40)\cos{78}} \]

\[ d = 42.5 \text{ mi} \]

\[ \frac{\sin{\theta}}{25} = \frac{\sin{78}}{42.5} \]

\[ \theta = 35.1° \]

Hence, \( (18 + 35.1) \) S of W.

\[ \text{Components} \]

\[ x = -25 \sin{30} + 40 \cos{18} + x = 0 \]

\[ x = -25 \sin{30} + 40 \cos{18} \]

\[ y = 25 \cos{30} + 40 \sin{18} + y = 0 \]

\[ y = 34.01 \]

8. (8 pts) Santa’s sleigh can fly 180 mph in still air. Santa wants to fly 370 miles due south to Knoxville. The wind is blowing due east at 55 mph. How long does it take Santa to get to Knoxville?

\[ \bar{V}_{s/G} = \bar{V}_{s/A} + \bar{V}_{A/G} \]

\[ V_{s/G}^2 + 55^2 = 180^2 \]

\[ V_{s/G} = 171.4 \text{ mi/hr} \]

\[ t = \frac{d}{V} = \frac{370}{171.4} \text{ hr} = 2.16 \text{ hr} \]
9. (8 pts) A 12 lb box is sliding down a ramp. Determine the acceleration.

\[ F_{BD} = KD \text{ required} \]

\[ 10.9 \text{ ft/s}^2 \]

\[ F = \mu_k N \]

\[ F = 0.35(9.46) = 3.31 \text{ lb} \]

\[ 12 \sin 38^\circ - 3.31 = \frac{12}{32.2} a_x \]

\[ a_x = 10.9 \text{ ft/s}^2 \]

\[ \mu_k = 0.35 \]

\[ \mu_s = 0.55 \]

10. (8 pts) A student throws a tennis ball off a 20 ft high tower at \((56\hat{i} + 32\hat{j})\) ft/s. How far from the base of the tower does the ball hit the ground?

\[ y: \quad y_2 = y_1 + v_{y1} t + \frac{1}{2} a_y t^2 \]

\[ 0 = 20 + 32t + \frac{1}{2}(-32.2 \text{ ft/s}) t^2 \]

\[ t = 2.49 \text{ sec} \]

\[ x: \quad x_2 = x_1 + v_{x1} t \]

\[ x_2 = 0 + 56(2.49) \]

\[ = 139 \text{ ft} \]

\[ \tan \theta = \frac{32}{56} \]

\[ \theta = 29.74^\circ \]

\[ 0 - 20 = x \tan(29.74^\circ) - \frac{32.2 \left( \frac{61 + 64.5^2}{2} \right) \text{ ft}}{x^2} \]

\[ v_0 = \sqrt{32.2^2 + 56^2} \]

\[ v_0 = 64.5 \]

\[ x = 139 \text{ ft} \]

**Switch** \( y \) & \( y_0 \)

\[ 27.5 \text{ or } 83.9 \text{ ft} \]

\[ -2 \]

Wrong solution

\[ -28 \text{ ft} \]

\[ 9.81 \text{ instead of } 32.2 \]

\[ 69.6 \text{ ft} \]

\[ -2 \]
11. (8 pts) A 15 kg object with an initial velocity of 7.0 m/s has a varying force \( F \) applied to it while moving up an incline. Determine the velocity of the object after it has traveled 10 m.

\[ v_f = 7.9 \text{ m/s} \]

\[ \frac{1}{2}(15)(7)^2 + 420 = \frac{1}{2}(15)v_f^2 + (15)(9.81)(10 \sin 13) \]

\[ \cos \text{ used for h } (-1) \]

\[ w = \text{area} = 60(4) + \frac{1}{2}(60)(6) = 420 \text{ N\cdotm} \]

2 pts

12. (8 pts) A tennis ball is thrown straight up. It hits and bounces off (coefficient of restitution 0.8) the concrete ceiling and eventually hits the ground with a speed of 42 ft/s. Determine the initial speed of the ball.

\[ v_1 = 42.2 \text{ ft/s} \]

\[ \frac{1}{2}mv_1^2 + mgh_3 = \frac{1}{2}mv_4^2 \]

\[ \frac{1}{2}v_3^2 + 32.2(18) = \frac{1}{2}(42)^2 \quad v_3 = 24.59 \text{ ft/s} \]

\[ e = \frac{(v_3 - v_c)}{v_2 - v_c} \Rightarrow 0.8 = \frac{(-24.59)}{v_2} \quad v_2 = 30.74 \text{ ft/s} \]

\[ \frac{1}{2}mv_4^2 = \frac{1}{2}mv_2^2 + mgh_2 \]

\[ \frac{1}{2}v_1^2 = \frac{1}{2}(30.74)^2 + 32.2(13) \quad v_1 = 42.2 \text{ ft/s} \]

COE between 1-2 & 3-4

\[ v = 38 \quad -4 \quad v = \frac{42}{38} = 1.1 \quad 87 \text{ switched } v_2 \text{ & } v_3 \text{ in e} \quad v_2 = 19.6 \quad v_1 = 35 \]

45.9 & 1-2 used 18 ft

Skipped 2nd COE -2
13. (8 pts) A car and truck collide and the result is an inelastic collision with the final velocities as shown. (They are NOT stuck together) Determine the initial speed of the car.

\[ v_C = 30.7 \frac{m}{s} \]

**BEFORE**

- Car 1800 kg
- Truck 3200 kg

**AFTER**

- Truck 3200 kg
- Car 1800 kg
- 10 m/s at 20°
- 24 m/s at 60°

\[ \text{COM: } x: \quad m_C v_{Cx} + m_T v_{Tx} = m_C v_{Cx}' + m_T v_{Tx}' \]

\[ v_{Cx} = v_{Cx}' + \frac{m_T}{m_C} v_{Tx}' \]

\[ v_{Cx} = 30.7 \frac{m}{s} = 10 \cos 20° + \frac{3200}{1800} 24 \cos 60° \]

\[ v_{Cx}' = 22.7 \frac{m}{s} \]

14. (8 pts) A 0.65 kg ball connected to a vertical post circles the post on a horizontal plane at a constant speed. Determine its speed in rpm. A separate, complete FBD = KD is required.

\[ v = 1.49 \frac{m}{s} \]

\[ a_n = \frac{3.96 \frac{m}{s^2}}{2.58} \]

\[ 6.877 \sin 22° = 0.65 \frac{v^2}{(0.5619)} \]

\[ w = 2.656 \frac{rev}{60 \text{ sec}} \]

\[ 25.4 \text{ rpm} \]

Switch sin/cos
\[ T = 17.02 N \rightarrow 62.7 \text{ rpm} \]
15. (8 pts) A Rube-Goldberg device uses a spring to propel a billiard ball up a ramp. The spring is initially compressed 10 cm, releases the ball from rest, and the ball rolls without slipping. What is the speed of the ball at the top of the ramp? (I_{sphere}=2/5m^2)

\[ v = \frac{2.55 \text{ m/s}}{5} \]

\[ m = 0.17 \text{ kg} \]
\[ r = 0.03 \text{ m} \]

\[ k=180 \text{ N/m} \]

\[ \frac{1}{2} k \cdot x^2 = \frac{1}{2} mv^2 + \frac{1}{2} I w^2 + mgh \]
\[ \frac{1}{2}(180)(0.1)^2 = \frac{1}{2}(0.17)v^2 + \frac{1}{2}(6.12 \times 10^{-5})(\frac{v^2}{0.03^2}) \]
\[ v = 2.55 \text{ m/s} \] and \( v = \omega r \) or \( w = \frac{v}{r} \)

16. (8 pts) A horizontal circular platform \((I = 42 \text{ kg-m}^2)\) spins freely about its center axis. A 3.0 kg fan mounted on the platform provides a constant force as shown. How many revolutions does the platform make in one minute if it starts from rest? (Hint: find angular acceleration first)

\[ 95.7 \text{ rev} \]

\[ I = I_0 + md^2 \]
\[ \alpha = \frac{F}{I} = \frac{30.07 \text{ Nm}}{90 \text{ kg m}^2} \]
\[ = 0.334 \text{ rad/sec}^2 \]

\[ \theta = \theta_0 + \omega_0 t + \frac{1}{2} \alpha t^2 \]
\[ = \frac{1}{2}(0.334)(60)^2 = 661.4 \frac{\text{rad}}{\text{rev}} \times \frac{2\pi \text{ rad}}{360 \text{ deg}} = 95.7 \text{ rev} \]