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SP211 Physics I | 50 Minute Exam | 26 Sep 2006

1. An object is traveling in a straight line along the y-axis where its position is given by:

$$x = (10\text{m})\cos\left(2\pi\frac{\text{rad}}{\text{s}}t\right)$$

where x is in meters and t is in seconds. For one dimensional motion it is acceptable to use a positive or negative sign to express the vector direction.

A. What is the **position at t = 0.25 sec**? (3 points)

$x = 10\text{m}\ \cos\left(2\pi\ \frac{\text{rad}}{\text{s}} \cdot 0.25\text{s}\right) = 10\text{m}\ \cos\left(\frac{\pi}{2}\text{rad}\right) = \boxed{0\text{ m}}$

B. What is the **velocity at t = 0.25 sec**? (5 points)

$v = \frac{dx}{dt} = -(10\text{m})\left(2\pi\ \frac{\text{rad}}{\text{s}}\right)\sin\left(2\pi\ \frac{\text{rad}}{\text{s}}t\right) = \left(-20\pi\ \frac{\text{m}}{\text{s}}\right)\sin\left(2\pi\ \frac{\text{rad}}{\text{s}} \cdot 0.25\text{s}\right)$

$= \left(-20\pi\ \frac{\text{m}}{\text{s}}\right)\sin\left(\frac{\pi}{2}\text{rad}\right) = \boxed{-20\pi\ \frac{\text{m}}{\text{s}} = -63\ \frac{\text{m}}{\text{s}}}$

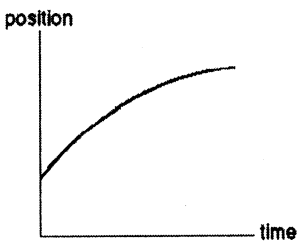
C. What is the **acceleration at t = 0.25 sec**? (5 points)

$a = \frac{dv}{dt} = -\left(20\pi\ \frac{\text{m}}{\text{s}}\right)\left(2\pi\ \frac{\text{rad}}{\text{s}}\right)\cos\left(2\pi\ \frac{\text{rad}}{\text{s}}t\right) = \left(-40\pi^2\ \frac{\text{m}}{\text{s}^2}\right)\cos\left(2\pi\ \frac{\text{rad}}{\text{s}} \cdot 0.25\text{s}\right)$

$= \left(-40\pi^2\ \frac{\text{m}}{\text{s}^2}\right)\cos\left(\frac{\pi}{2}\text{rad}\right) = \boxed{0\ \frac{\text{m}}{\text{s}^2}}$

D. A train moves along a straight track according to the graph below. The train (2 points):

a. speeds up the whole time
(b.) slows down the whole time
c. speeds up part of the time and slows down part of the time
d. moves at constant velocity



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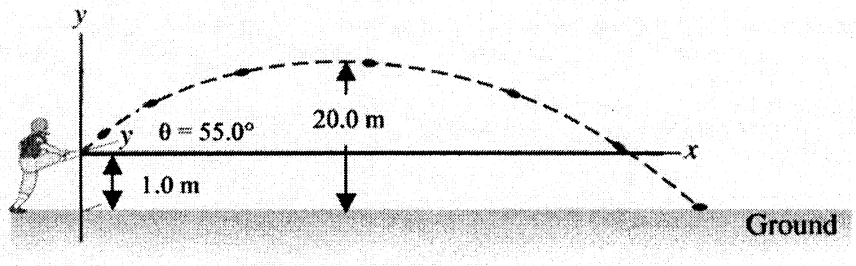
3. (20 pts) An NFL punter kicks a football at angle of 55.0 degrees to horizontal. The ball reaches a peak height of 20.0 meters above the ground. Assume he held the ball 1.00 meter above the ground when he kicked it.



A. What is the **y-component** of the football's **initial velocity**? (5 points)

$$v_y^2 = v_{y_0}^2 + 2a(y - y_0) = 0$$

$$v_{y_0}^2 = +2g(y - y_0)$$

$$v_{y_0} = \sqrt{2g(y - y_0)} = \sqrt{2(9.8\,m/s^2)(19\,m)} = \boxed{19.3\ m/s}$$

B. How **long is the football in the air** before it hits the ground? (5 points)

$$y = y_0 + v_{y_0}t - \tfrac{1}{2}gt^2$$

$$0 = 1\,m + 19.3\,m/s\ t - 4.9\,m/s^2\ t^2$$

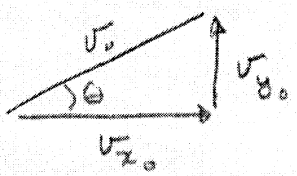
$$t = \frac{-19.3\,m/s \pm \sqrt{(19.3\,m/s)^2 - 4(-4.9\,m/s^2)(1\,m)}}{-9.8\,m/s^2} = \frac{-19.3 - 19.8}{-9.8} = \boxed{3.99\,s}$$

OR $-0.051\,s$

C. Using the given angle, what is the **x-component** of the football's **initial velocity**? (5 points)

$$\tan\theta = \frac{v_{y_0}}{v_{x_0}}$$

$$v_{x_0} = \frac{v_{y_0}}{\tan\theta} = \frac{19.3\,m/s}{\tan 55} = \boxed{13.5\ m/s}$$



D. How far did the ball **travel in the x-direction**? (5 points)

$$x = v_{x_0}t = (13.5\,m/s)(3.99\,s) = \boxed{53.9\ m}$$

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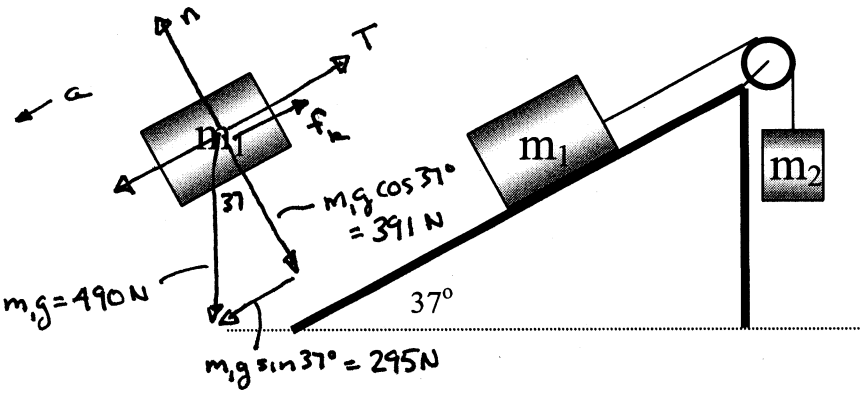
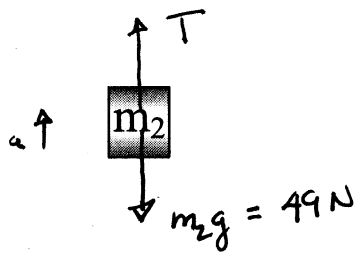
4. Two blocks connected by a cord passing over a massless, frictionless pulley are initially at rest as shown. Static friction will not prevent the blocks from moving. The coefficient of kinetic friction between m_1 and the horizontal surface, μ_k, is 0.20.

$m_1 = 50.$ kg and $m_2 = 5.0$ kg.

Free Body Diagram 1



Free Body Diagram 2



A. **Draw and label all forces on two free body diagrams used to** represent the two blocks in the above sketch. Apply N2L to **write three force** equations for this system. (5 points)

$$n - m_1 g \cos 37 = n - 391\,N = 0$$

$$m_1 g \sin 37° - T - f_k = m_1 a = 295\,N - T - f_k = (50\,kg)\,a$$

$$T - m_2 g = m_2 a = T - 49\,N = (5\,kg)\,a$$

B. Calculate the **friction force.** (5 points)

$$n = 391\ N$$

$$f_k = \mu_k n = 0.20\,(391\,N) = \boxed{78.2\,N}$$

C. What is the **acceleration** of the blocks? (5 points)

$$295\,N - T - 78.2\,N = (50\,kg)\,a = 217\,N - T = (50\,kg)\,a$$

$$T - 49\,N = (5\,kg)\,a$$

$$217\,N - 49\,N = (50\,kg + 5\,kg)\,a \Rightarrow a = \boxed{3.1\ m/s^2}$$

$$168\,N = 55\,kg\ a$$

D. What is the **tension in the connecting string**? (5 points)

$$T = 49\,N + (5\,kg)(a) = 49\,N + (5\,kg)(3.1\,m/s^2)$$

$$= \boxed{64\,N}$$

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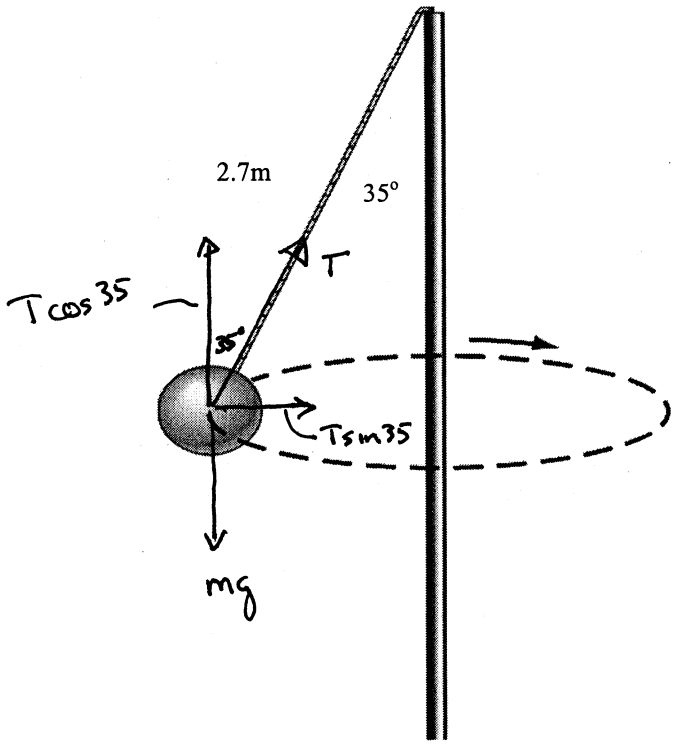
4. At the beginning of a tether-ball game, a young child hits the ball so that it swings around and the rope makes an angle of 35° with the vertical. If the rope is 2.7 m long and the ball has a mass of 0.4 kg,



A. What is the **tension** in the string? (7 points) For full credit, you must draw a free body diagram and label all forces.

$$T\cos 35 - mg = 0$$

$$T = \frac{mg}{\cos 35} = \frac{(0.40\text{kg})(9.8\text{m/s}^2)}{\cos 35^\circ} = \boxed{4.8\text{ N}}$$

B. How **fast** is the ball traveling? (5 points)

$$T\sin 35 = m\frac{v^2}{r} \qquad r = 2.7\text{m}\sin 35^\circ = 1.55\text{m}$$

$$4.8\text{N}\sin 35 = 2.74\text{N} = (.4\text{kg})\frac{v^2}{1.55\text{m}}$$

$$v^2 = 10.6\frac{\text{m}^2}{\text{s}^2} \Rightarrow v = \boxed{3.3\text{ m/s}}$$

C. How **long does it take to complete 1 revolution**? (3 points)

$$T = \frac{2\pi r}{v} = \frac{2\pi(1.55\text{m})}{3.26\text{m/s}} = 2.99\text{ s} = \boxed{3\text{ s}}$$