KEY

PHYS 1211 Fall 2021 Test 2

October 14, 2021

Name _____ **Student ID** _____ **Score** _____

Note: This test consists of one set of conceptual questions, five problems, and a bonus problem. For the problems, you *must show all* of your work, calculations, and reasoning clearly to receive credit. Be sure to include units in your solutions when appropriate. An equation sheet is provided on the last pages.

Problem 1. Conceptual questions. State whether the following statements are *True* or *False*. (10 points total, no calculations required)

(a) According to Newton's 1st law, the laws of physics are equally valid in a reference frame that is at rest and a reference frame moving at a constant velocity.

True

(b) For an object in uniform circular motion, its tangential acceleration is constant.

False → v_t = constant

(c) The kinetic energy depends on the direction of motion of the object.

False $K = \frac{1}{2}mv^2$ is a scalor

α = constant

Problem 2. A compact disk, which has a diameter of 12.0 cm, speeds up uniformly from rest to 4.00 rev/s in 3.00 s. What is the tangential acceleration of a point on the rim of the disk at 3.00 s? (15 points total)

$t_i = 0,\ t_f = 3.0\,s,\ r = 0.06\,m$

Use $\omega_f = \omega_i + \alpha t_f$ $\quad \omega_i = 0,\ \omega_f = 4\frac{rev}{s} \times \frac{2\pi\ rad}{1\ rev} = 25.132\frac{rad}{s}$

$$\alpha = \frac{\omega_f - \omega_i}{t_f} = \frac{25.132 - 0}{3} = 8.377\ rad/s^2$$

$$a_t = r\alpha = (0.06m)\left(8.377\frac{rad}{s^2}\right) = \boxed{0.503\frac{m}{s^2}}$$

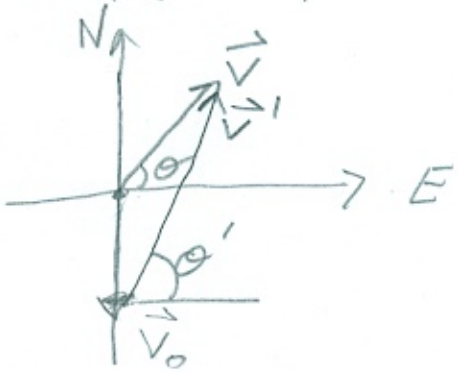
Problem 3. You are riding upstream on a Jet Ski on a river which is flowing South at a speed of 2.8 m/s with respect to the riverbank. Your velocity is 9.5 m/s at an angle of 20.0° North of East also with respect to the riverbank. What is your speed with respect to the flowing river if your velocity vector is at an angle of 35.0° North of East? (15 points total)

$\vec{V}_0 = \vec{V}_{river} = -2.8\frac{m}{s}\hat{j}$

$\vec{V} = 9.5\,m/s$ @ $20.0°$ N of E

Find $\vec{V}'$ = your velocity wrt river

Use $\vec{V}' = \vec{V} - \vec{V}_0$



$V_x' = V\cos\theta + 0 = V'\cos\theta'$

$V_y' = V\sin\theta - V_0$

$$V' = \frac{V\cos\theta}{\cos\theta'} = \frac{9.5\cos 20°}{\cos 35°} = \boxed{10.9\,m/s}$$

or

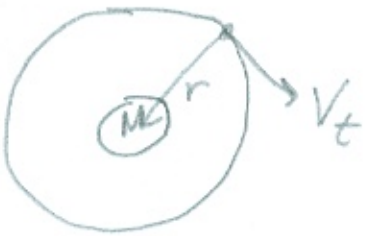
$V'\sin\theta' = V\sin\theta - V_0 \Rightarrow V' = \frac{V\sin\theta - V_0}{\sin\theta'} = \frac{9.5\sin 20° - (-2.8)}{\sin 35°}$

$= \boxed{10.5\,m/s}$ ← accept either

Problem 4. One of the Starlink satellites moves in a circular orbit about the Earth at a speed of 5500 m/s. What is its orbital period? (15 points total)

$V_t = \frac{2\pi r}{T} = V = \sqrt{\frac{GM}{r}}$ = orbital speed

$\Rightarrow r = \frac{GM}{V^2}$

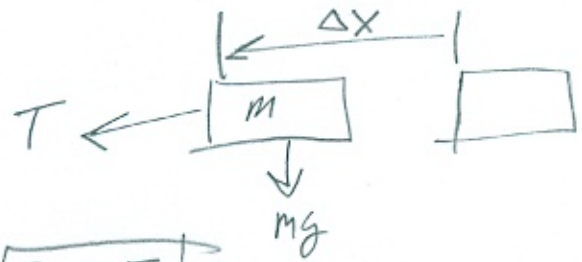


$V_t = \frac{2\pi}{T}\left(\frac{GM}{V_t^2}\right) \Rightarrow T = \frac{2\pi GM}{V^3}$

$T = \frac{2\pi (6.67\times10^{-11})(5.98\times10^{24})}{(5500)^3} = \frac{1.506\times10^4 s}{} = \boxed{4.18 hrs}$

Problem 5. A horizontal rope with 15 N tension drags a 25 kg box of Halloween chocolate 2.0 m to the left across a horizontal surface. How much work is done by (a) the tension force? (b) gravity? (15 points total)

a) $W = F\cos\phi\,\Delta x$



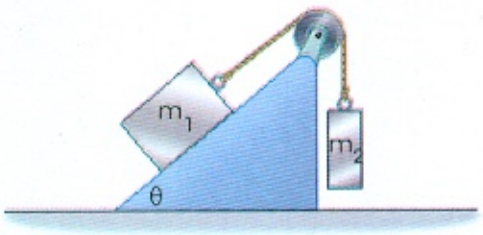
$W_T = T\cos 0^\circ \Delta x$

$= (15N)(1)(2.0m) = \boxed{30 J}$

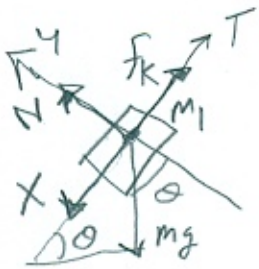
b) $W_g = (mg)\cos\phi\,\Delta x = mg\Delta x \cos 90^\circ = \boxed{0}$

Problem 6. Two blocks are connected by a string as shown in the figure. If $\theta = 30.0°$, $m_1 = 10.0$ kg, and $m_2 = 0.5$ kg, determine the acceleration of m_1. The friction coefficients between m_1 and the incline surface are $\mu_s = 0.7$ and $\mu_k = 0.5$. Determine the tension in the string. Hint: draw free-body diagrams. (30 points total)

Newton's 2nd Law problem



FBDs



m_1

$+\nwarrow \sum F_y = m_1 a_{1y}$

$N - m_1 g\cos\theta = 0$

$N = m_1 g\cos\theta$

$+\swarrow \sum F_x = m_1 a_{1x}$

$m_1 g\sin\theta - f_k - T = m_1 a_{1x}$

$m_1 g\sin\theta - \mu_k N - T = m_1 a$

$m_1 g\sin\theta - \mu_k m_1 g\cos\theta - m_2(g+a) = m_1 a$

$m_1 g\sin\theta - \mu_k m_1 g\cos\theta - m_2 g = (m_1 + m_2)a$

or

$$a = \frac{m_1 g(\sin\theta - \mu_k\cos\theta) - m_2 g}{m_1 + m_2} = \frac{(10)(9.8)(\sin 30° - 0.5\cos 30°) - 0.5(9.8)}{10.5}$$

$= \boxed{0.1585\ m/s^2}$

m_2

$+\uparrow \sum F_y = m_2 a_{2y}$

$T - m_2 g = m_2 a_{2y}$

$T = m_2(g + a_{2y})$

need a_{2y}

now $a_{1x} = a_{2y} = a$

$T = 0.5(9.8 + 0.1585)$

$= \boxed{4.98\ N}$

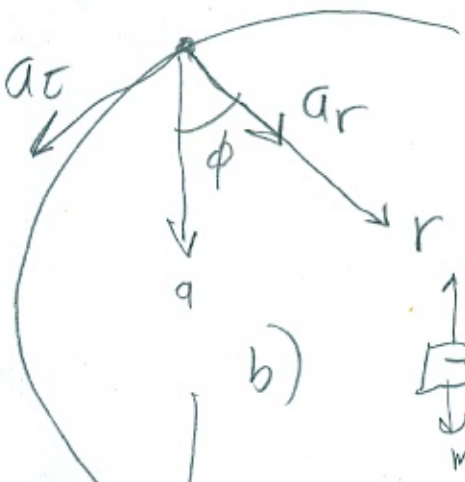
Bonus Problem. A 1500 kg car starts from rest and drives around a flat 50-m-diameter circular track. The forward force provided by the car's drive wheels is a constant 1000 N. (a) What are the magnitude and direction of the car's acceleration at $t = 10$ s? Give the direction as an angle from the r-axis. (b) If the coefficient of static friction between the rubber tire and concrete track is $\mu_s = 1.0$, at what time does the car begin to slide out of the circle? (5 points total)

$\Sigma F_T = ma_T$

$F_T = ma_T$

$a_T = \frac{F_T}{m} = \frac{1000\,N}{1500\,kg}$

$= 0.6667\ m/s^2$



get V_f, $V_f = V_i + a_T t_f$

$= (0.6667)(10s) = 6.6667\ m/s$

$a_r = \frac{V_t^2}{r} = \frac{(6.6667)^2}{(25)} = 1.778\ m/s^2$

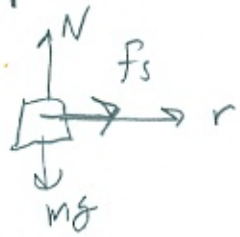
$a = \sqrt{a_t^2 + a_r^2} = \sqrt{0.6667^2 + 1.778^2}$

$\boxed{a = 1.8989\ \frac{m}{s^2}}$

$\phi = \cos^{-1}\left(\frac{a_r}{a}\right) = \cos^{-1}\left(\frac{1.7778}{1.8985}\right)$

$\boxed{\phi = 20.6^\circ}$

b)



$\Sigma F_y = N - mg = 0$

$\Sigma F_r = f_s = \frac{mV^2}{r}$

$\mu_s N = \frac{mv^2}{r}$

$\mu_s mg = \frac{mv^2}{r}$

$V = \sqrt{\mu_s r}$ = max speed $= V_f$

$V_f = V_i + a_T t_f$

$V_f = 0 + a_T t_f$

$t_f = \frac{V_f}{a_T} = \frac{\sqrt{\mu_s r}}{a_T}$

$= \frac{\sqrt{1(25)}}{0.6667} = \boxed{7.5\,s}$