Physics 10154 - Exam #7C

Answer the following two questions. Be sure to clearly indicate your answer with a circle or box. Show all work. If I cannot see how you arrived at an answer, I will deduct points!

1. A 1500-kg race car accelerates from rest on a circular track of radius 350 meters at a rate of 0.75 m/s^2. At the point where the magnitudes of the centripetal and tangential accelerations are equal, determine:

a) The speed of the race car (meters/sec)
b) The total distance travelled around the track (meters).

c) If the race car moves at a constant speed (from part a) around the circular track but is on the verge of slipping radially outward, what is the coefficient of static friction between the car's tires and the ground?

a) $\frac{v^2}{r} = 0.75 \Rightarrow v^2 = (0.75)(350) \Rightarrow \boxed{v = 16.2 \, m/s}$

b) $\Delta s =$

$v_0 = 0$

$v = 16.2 \, m/s$

$a = 0.75 \, m/s^2$

$t =$

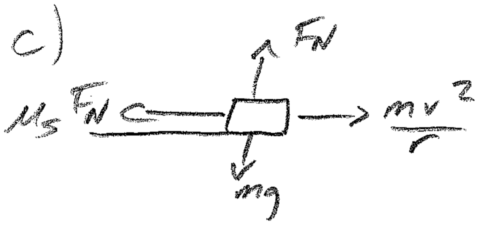
$v^2 = v_0^2 + 2a\Delta s$

$16.2^2 = 0 + 2(.75)\Delta s$

$\Delta s = 175 \, m$

or $\boxed{180 \, m}$

c)



$\Sigma F_{rad} = \frac{mv^2}{r} - \mu_s F_N = 0$

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

$\mu_s = \frac{v^2}{rg}$

$= \frac{(16.2)^2}{(350)(9.8)} = \boxed{.077}$

2. A 550-kg satellite is launched into a circular orbit with an altitude of 1200 km above the Earth's surface. The initial speed of the satellite due to the speed of Earth's rotation is 464 m/s.

a) What is the orbital speed of the satellite at its final altitude?

b) What is the period of its orbit?

c) Assuming no friction, how much work must be done by the rocket's engines to put this satellite into orbit? Hint: You may not use any form of mgh for work done by gravity here since acceleration and gravitational force are not constant. Don't forget about the change in kinetic energy!

a) $v = \sqrt{\frac{GM}{r}}$ $\quad r = R_E + h = 6.38\times10^6 + 1.20\times10^6$

$= 7.58\times10^6\,m$

$v = \sqrt{\frac{(6.67\times10^{-11})(5.98\times10^{24})}{7.58\times10^6}} = \boxed{7250\ m/s}$

b) $T = \frac{2\pi r}{v} = \frac{2\pi(7.58\times10^6)}{7250} = 6566\,s$

or $\boxed{1.8\ hrs}$

c) $\Sigma W_F = W_{grav} + W_{engines} = \Delta K$

$U_i - U_f + W_{eng} = K_f - K_i$

$W_{eng} = K_f + U_f - K_i - U_i$

$K_f = \frac{1}{2}mv^2 = \frac{1}{2}(550)(7250)^2 = 1.445\times10^{10}\,J$

$K_i = \frac{1}{2}mv_0^2 = \frac{1}{2}(550)(464)^2 = 5.9\times10^7\,J$

$U_f = -\frac{GMm}{r} = -\frac{(6.67\times10^{-11})(5.98\times10^{24})(550)}{7.58\times10^6} = -2.894\times10^{10}\,J$

$U_i = -\frac{GMm}{R_E} = -\frac{(6.67\times10^{-11})(5.98\times10^{24})(550)}{6.38\times10^6} = -3.439\times10^{10}\,J$

$W_{eng} = 1.445\times10^{10} - 2.894\times10^{10} - 5.9\times10^7 + 3.439\times10^{10} = \boxed{1.98\times10^{10}\,J}$