Phys 10154 - Fall 2006 - Exam #7B

Be sure to answer with the proper units and significant figures. Indicate your answers clearly with boxes. SHOW ALL WORK. Even if your answer is correct, I will deduct points if I can't see how you solved the problem. Both problems are worth 50 points.

1. A small flat block rests on the surface of a merry-go-round, right at edge, 1.5 meters from the center of rotation. The merry-go-round starts into motion, accelerating at an angular rate of 0.25 rad/sec2. After 3.0 seconds have elapsed, find:

a) The angular velocity
b) The linear distance covered by the block
c) The centripetal acceleration of the block (magnitude only)
d) The total acceleration (magnitude and direction)

$\Delta\theta =$
$\omega_0 = 0$
$\omega =$
$\alpha = 0.25\ \text{rad/s}^2$
$t = 3.0\ \text{s}$

$\Delta\theta = \omega_0 t + \frac{1}{2}\alpha t^2$
$= 1.125\ \text{rad}$

$\omega = \omega_0 + \alpha t$
$= 0.75\ \text{rad/s}$

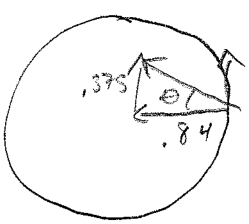
a) $\boxed{\omega = 0.75\ \text{rad/s}}$

b) $\Delta s = r\Delta\theta = \boxed{1.7\ \text{m}}$

c) $a_{cent} = r\omega^2 = (1.5)(.75)^2 = \boxed{0.84\ \text{m/s}^2}$

d) $a_{tan} = r\alpha = 0.375\ \text{m/s}^2$

$a_{tot} = \sqrt{a_c^2 + a_t^2} = \boxed{0.92\ \text{m/s}^2}$



$\theta = \tan^{-1}\left(\frac{.375}{.84}\right) = \boxed{24° \text{ ahead of radially inward}}$

2. The space shuttle is in orbit around the Earth at an altitude of 850 miles above the surface. From there, it releases a 650-kg satellite that will go into a geosynchronous orbit (period of 23 hours and 56 min).

a) What is the orbital speed of the shuttle, in meters/sec?

b) What will be the final orbital speed of the satellite when it reaches geosynchronous orbit?

c) How much work will gravity do on the satellite as it climbs from 850 miles to its final orbital position?

The Mass of Earth is 5.98×10^{24} kg
The Radius of Earth is 6.38×10^{6} m
The Gravitational Constant is 6.67×10^{-11} N-m^2/kg^2

a) $V_{orbit} = \sqrt{\dfrac{GM}{r_{orbit}}} = \sqrt{\dfrac{(6.67\times10^{-11})(5.98\times10^{24})}{7.75\times10^{6}}}$

$r_{orbit} = 6.38\times10^{6} + 1.37\times10^{6} = 7.75\times10^{6}\ m$

$V_{orbit} = \boxed{7200\ m/s}$

b) $T = 23h\ 56m = 86160$

$r^3 = \left(\dfrac{GM}{4\pi^2}\right)T^2 = \dfrac{(6.67\times10^{-11})(5.98\times10^{24})(86160)^2}{4\pi^2}$

$r^3 = 7.5\times10^{22}$

$r = 4.22\times10^{7}\ m$ $\quad V_{orbit} = \sqrt{\dfrac{(6.67\times10^{-11})(5.98\times10^{24})}{4.22\times10^{7}}}$

$= \boxed{3100\ m/s}$

c) $U_i = -\dfrac{GMm}{r_1} = \dfrac{(6.67\times10^{-11})(5.98\times10^{24})(650)}{7.75\times10^{6}} = -3.345\times10^{10}\ J$

$U_f = -\dfrac{GMm}{r_2} = -\dfrac{(\ )(\ )(\ )}{4.22\times10^{7}} = -6.144\times10^{9}$

$W_{grav} = -(U_f - U_i) = U_i - U_f = \boxed{-2.7\times10^{10}\ J}$