Circular Motion I

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Wahoo!

Where a numerical value is required, take $g = 9.8ms^{-2}$ and $c = 3 \cdot 10^8 ms^{-1}$.

1. A certain computer scientist is vaulting through space. He manages to begin orbiting the milky way, lapping around 36000 times per hour. If the radius of his orbit is 49000 light-years, find his forward velocity perpendicular to the centripetal force.

2. (a) A farmer is participating in an Formula One race in his tractor. The race takes place on a banked track with radius $30m$ with angle of inclination ϑ. He is moving at $0.49ms^{-1}$ and is not slipping. Find ϑ in radians to three significant figures.

   (b) The farmer decides to vengefully join the same Formula One race the next year, this time having upgraded his tractor in many ways, including an engine powered by nuclear fusion. He starts from a velocity of $1ms^{-1}$, but his speed increases exponentially. As the tractor gets faster, find the value (again, in radians) that the angle ϑ at which the tractor never slips approaches as the tractor gets faster.

3. To celebrate his victory, the farmer now decides to have some fun by messing with a certain rabbit that has been mucking about in his farm recently. He spins around the rabbit a carrot of mass 49 g on the end of a smooth inextensible string, in a circular path of radius $3m$. Given that the angle between the fishing rod and the vertical is $15°$, find the tension T in the string and the angular velocity of the carrot ω.

Solutions

1. $r = 4.635792 \cdot 10^{20} m, \omega = 20\pi \text{ rad } s^{-1}$

   $\therefore v = 2.913 \cdot 10^{22} m s^{-1}$

2. (a) $81.7 \cdot 10^{-6}$

   (b) $\frac{\pi}{2}$

3. $T = 0.4971N$

   $\omega = 0.2989 \text{ rad } s^{-1}$