

# Circular Motion I

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Wahoo!

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

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 a ██████████ race in his tractor. The race takes place on a banked track with radius  $30m$  with angle of inclination  $\vartheta$ . He is moving at  $0.49ms^{-1}$  and is not slipping. Find  $\vartheta$  in radians to three significant figures.  
(b) The farmer decides to vengefully join the same ██████████ 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  $\vartheta$  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  $49g$  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  $15^\circ$ , find the tension  $T$  in the string and the angular velocity of the carrot  $\omega$ .

## 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.  $T = 0.4971 N$

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