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Physics worksheet solutions – Uniform circular motion

Q1a A 1200-kg car travels at 32 ms^{-1} for 3 minutes around a circular track of radius 450 m. Find the number of complete laps finished by the car.

$\frac{32\times 3\times 60}{2\pi\times 450}\approx 2.04$, 2 complete laps

Q1b Determine the acceleration of the car while it is in motion.

$\frac{32^2}{450}\approx 2.3\ ms^{-2}$

Q1c Find the magnitude of the average velocity of the car in one half of a lap.

$\Delta t=\frac{1}{2}\times\frac{2\pi\times 450}{32}\approx 44.18\ s$

$|v_{av}|=\frac{|s|}{\Delta t}=\frac{2\times 450}{44.18}\approx 20.4\ ms^{-1}$

Q1d Find the magnitude of the average acceleration of the car in one half of a lap.

$|a_{av}|=\frac{|\Delta v|}{\Delta t}=\frac{2\times 32}{44.18}\approx 1.4\ ms^{-2}$

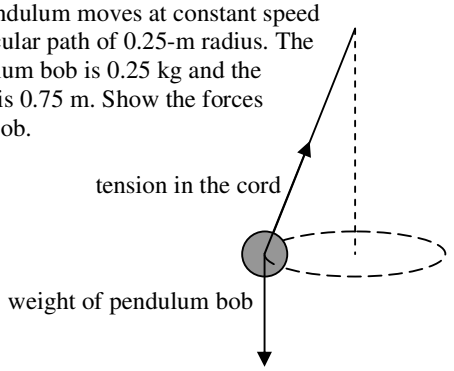
Q1e Determine the centripetal force of friction on the tyres to keep the car moving around the circular track at 32 ms^{-1}.

$F=ma=1200\times\frac{32^2}{450}\approx 2.7\times 10^3\ N$

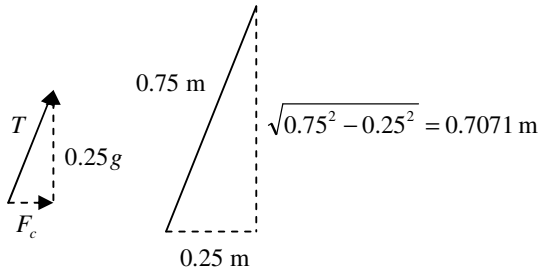
Q1f The car will skid out of control if the centripetal force of friction on the tyres reaches 3200 N. Determine the speed range for safe driving.

$3200=1200\times\frac{v^2}{450}$, $v\approx 34.641$, range $v<34.6\ ms^{-1}$

Q2a A conical pendulum moves at constant speed in a horizontal circular path of 0.25-m radius. The mass of the pendulum bob is 0.25 kg and the length of the cord is 0.75 m. Show the forces on the pendulum bob.



Q2b Determine the tension in the cord.



$\frac{T}{0.25g}=\frac{0.75}{0.7071}$, $T\approx 2.6$ N

Q2c Calculate the acceleration of the pendulum bob.

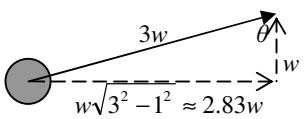
$\frac{F_c}{0.25g}=\frac{0.25}{0.7071}$, $T\approx 0.87$ N

$a=\frac{F_c}{m}\approx\frac{0.87}{0.25}\approx 3.5\ ms^{-2}$

Q2d Calculate the speed of the pendulum bob.

$v=\sqrt{ar}\approx\sqrt{3.5\times 0.25}\approx 0.93\ ms^{-1}$

Q2ei The cord can support a tension up to 3 times the weight of the pendulum bob. Determine the maximum angle the cord makes with the vertical while the pendulum bob is in motion.



$\theta=\cos^{-1}\frac{w}{3w}\approx 70.5°$

Q2eii Calculate the maximum speed of the pendulum bob.

Centripetal force $F_c\approx 2.83mg=2.83\times 0.25\times 9.8\approx 6.93$ N

Radius $r\approx 0.75\sin 70.5°\approx 0.7071$ m

$v=\sqrt{\frac{F_c r}{m}}\approx\sqrt{\frac{6.93\times 0.7071}{0.25}}\approx 4.4\ ms^{-1}$