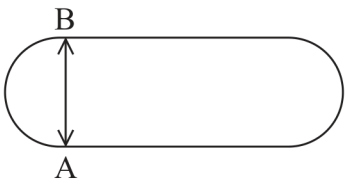
14 A track for go-karts is being built in a park.

The design criteria state that the track must have semicircular ends with straight track in between, as shown.



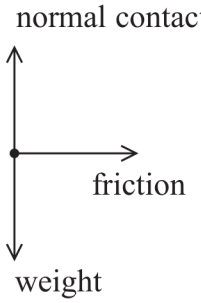
The track must allow the go-kart to travel safely at speeds up to 35.0 km per hour (9.72 m s^{-1}) on the bends.

mass of go-kart and driver = 185 kg

diameter AB of semicircular end = 30.0 m

(a) For one design the track is horizontal.

As the go-kart goes round the semicircular end of the track, centripetal force is provided by friction between the track and the tyres. This is shown in the free body force diagram below.



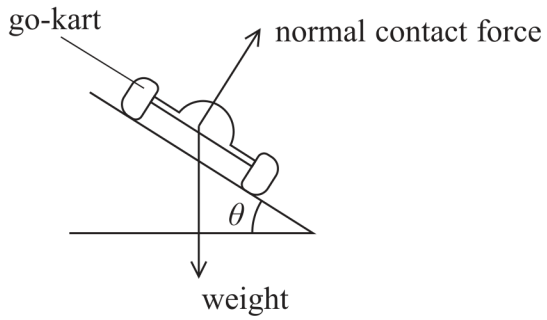
Not to scale

Show that this design meets the design criteria.

maximum frictional force = 1180 N

(2)

(b) A second design uses a track that is banked at the semicircular ends. The track is banked at an angle θ to the horizontal.



At a particular speed v, the go-kart can follow the track without any frictional force perpendicular to its motion. The diagram shows the forces on the go-kart as it is moving away.

(i) Show that $\tan\theta = \dfrac{2v^2}{gd}$

where d is the diameter AB of the curved part of the track.

(3)

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(ii) Calculate the angle θ using the stated design criteria for this track.

(2)

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Angle = ...

(c) A banked track will cost more to build.

Suggest whether there are any significant advantages that would justify the cost.

(2)

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(Total for Question 14 = 9 marks)

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