## Challenge Questions

Name: $\qquad$ Date: $\qquad$

1. When you whirl a ball on a cord in a vertical circle, you find a critical speed at the top for which the tension in the cord is zero. This is because the force of gravity on the object itself supplies the necessary centripetal force. How slowly can you swing a 2.5 kg ball like this so that it will just follow a circle with a radius of 1.5 m ?
[ Ans: $3.8 \mathrm{~m} / \mathrm{s}$ ]
2. Snoopy is flying his vintage war plane in a "loop the loop" path chasing the Red Baron. His instruments tell him the plane is level (at the bottom of the loop) and traveling with a speed of $180 \mathrm{~km} / \mathrm{h}$. He is sitting on a set of bathroom scales, and notes that they read four times the normal force of gravity on him. What is the radius of the loop? Answer in metres. (SIN '75) [ Ans: 85 m ]

3. A stuntman drives a car over the top of a hill, the cross section of which can be approximated by a circle of radius 250 m , as in the figure. What is the greatest speed at which he can drive without the car leaving the road at the top of the hill? [ Ans: 178 km/h]
4. A mass of 6 kg is attached to a string and is rotating in a horizontal plane on a frictionless surface. The mass makes 72 revolutions in 12 seconds. Another mass is also attached to the same rope, but closer to the centre of rotation ( 6 cm from the centre to be exact). The mass that is further from the centre is moving at 2 times the tangential speed of the other mass. Calculate the separation of the two masses.
5. A mass of $m(=2 \mathrm{~kg})$ on a frictionless table is attached to a hanging mass $M(=3 \mathrm{~kg})$ by a cord through a hole in the table the radius of the string is 1.0 m . Find the speed at with which $m$ must move for $M$ to:
a) remain stationary ( $a=0 \mathrm{~m} / \mathrm{s}^{2}$ )
b) accelerate upwards at $1.0 \mathrm{~m} / \mathrm{s}^{2}$
c) accelerate downwards at $1.0 \mathrm{~m} / \mathrm{s}^{2}$

[ Ans: a) $3.83 \mathrm{~m} / \mathrm{s} \quad$ b) $4.02 \mathrm{~m} / \mathrm{s} \quad$ c) $3.63 \mathrm{~m} / \mathrm{s}$ ]
6. An Australian bushman hunts kangaroos with the following weapon, a heavy rock tied to one end of a light vine of length 2 m . He holds the other end above his head, at a point 2 m above the ground level, and swings the rock in a horizontal circle. The cunning kangaroo has observed that the vine always breaks when the angle theta (measured between the vine and the vertical) reaches 600. At what minimum distance from the hunter can the kangaroo stand with no danger of a direct hit? (SIN '72)
[ Ans: 3.0 m ]
7. If a curve with a radius of 60 m is properly banked for a car traveling $60 \mathrm{~km} / \mathrm{h}$ (for no friction), what must the coefficient of friction for a car not to skid when traveling at 90 $\mathrm{km} / \mathrm{h}$ ?
[ Ans: 0.393 ]

