Problem Set No. 9

UBC Metro Vancouver Physics Circle 2018-2019

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1 Evel Knievel and the Crocodile Pit

Evel Knievel rides his stunt motorcycle over a semicircular ramp of radius R. He is planning to use this ramp to shoot his motorbike over a pit of ravenous Alabama crocodiles, of length L, immediately after the ramp. His motorcycle can achieve a maximum speed of v, and for simplicity, we assume Knievel can accelerate to this speed instantaneously and at will.

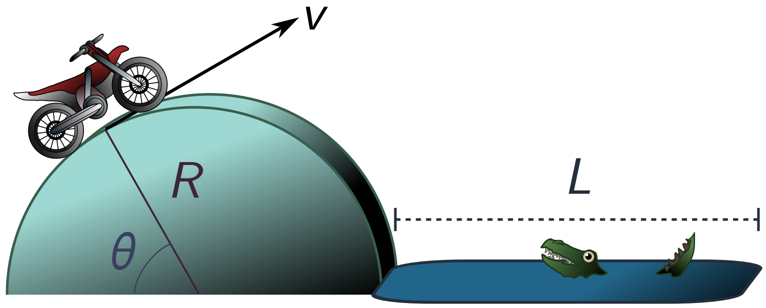

Figure 1: Evil Knievel jumping over a pit of crocodiles.

1. Label the angle from the horizontal by θ. What condition must v satisfy to launch Knievel at an angle θ?

2. Show that if Knievel launches at angle θ, his airtime is

$$t = \frac{1}{g}\left[vc_\theta + \sqrt{v^2c_\theta^2 + 2gRs_\theta}\right],$$

   where $s_\theta = \sin\theta$ and $c_\theta = \cos\theta$.

3. Deduce that after launching at θ, his range over the crocodile pit is

$$r = \frac{v^2 s_\theta}{g}\left[c_\theta + \sqrt{c_\theta^2 + \frac{2gRs_\theta}{v^2}}\right] - R(1 + c_\theta).$$

4. The range is a very unpleasant function to optimise. Instead, let's study a special case. Suppose that Knievel launches horizontally at the top of the ramp with $\theta = \pi/2$. What does v need to be to clear the crocodile pit?

5. For $\theta = \pi/2$, use part (1) to demonstrate that he will *automatically* clear the pit provided

$$(\sqrt{2} - 1)R > L.$$

2 Simply Let Go

A ball is released from point (x_0, y_0) on top of an incline with angle θ to score a bucket placed at the bottom of the incline (ignore the height and width of the bucket relative to x_0 and y_0).

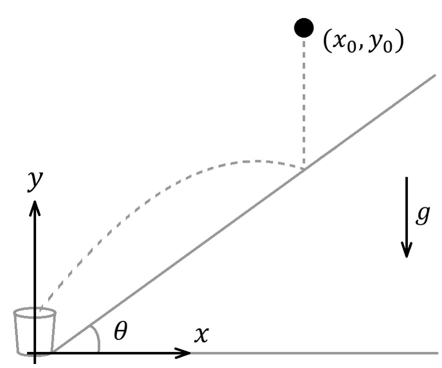

Figure 2: The release of the ball and subsequent scoring of the bucket.

1. If the ball were to hit the incline only once, as shown above, what set of initial coordinates would allow it to enter the bucket?

2. Generalize the results from part (1) to N collisions with the incline (this is tricky!).

3. What conditions should x_0 and y_0 satisfy when $N = 0$ and $N \to \infty$? First, answer using your intuition and then confirm with the result from part (2).