Challenge Problem Set 2

(Nayana Rajapakse)

① A projectile is launched from ground level at a speed of V_0 and an angle θ above the horizontal. Consider the specific moment where its instantaneous velocity makes an angle α below horizontal.

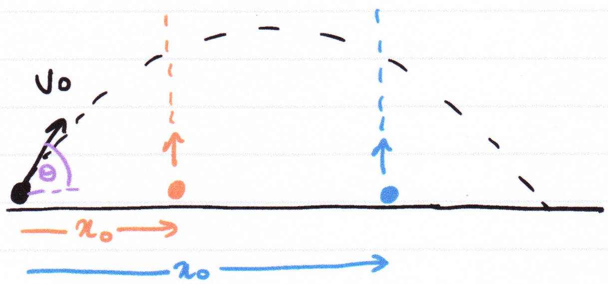
(a) Find the time taken up to that point from the launch.

(b) Find horizontal and vertical displacements.

(c) Deduce the results for parts (a) & (b) when $\alpha = \theta$.

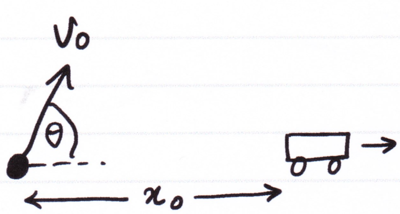
(d) Comment on the results got in part (d).

② A projectile is launched at speed V_0 with an angle θ above horizontal level. A ball is thrown straight up at the same time with velocity V at a location x_0 away from the projectile launch. Assume x_0 is within the range of the projectile.



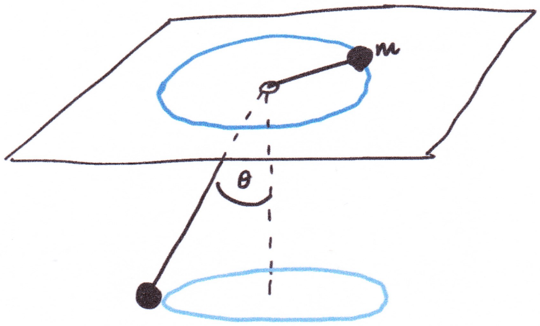
Find 'v' so that the two objects will collide midair.

③



As shown in the diagram a projectile must be launched that it will hit a moving car. You have control over θ but V_0 is predetermined. At the time of projectile $(t=0)$, the car is a horizontal distance x_0 away from the launch. Car starts from rest and accelerates uniformly at an acceleration of 'a'. Assume that V_0 is sufficiently large that the projectile can indeed hit the car for the given 'x_0' & 'a'. Find the required θ.

(4)

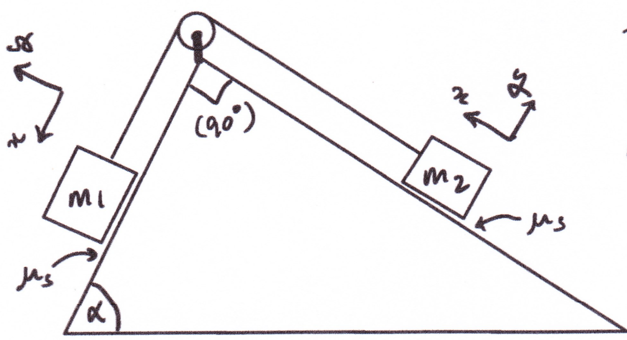


Two point masses each with mass 'm' are connected with a rope with length 'l' which goes through a hole of a horizontal plane as shown. Plane is frictionless. As shown, both are performing circular motion with equal tangential speed.

(a) Find an expression for the length of the segment of the rope on the horizontal plane in terms of θ and l.

(b) Show the answer obtained for part (a) is dimentionally consistant.

(5)



Two blocks with masses m_1 & m_2 are connected with a string that goes around a pulley as shown. As marked static friction coefficient is μ_s for both sides.

(a) Show that for the system to be in equilibrium without any assistance from frinction, $\tan\alpha = m_2/m_1$ must be satisfied.

(b) Now consider the case $\tan\alpha > m_2/m_1$ yet α is small enough that the system is in equilibrium. For the given m_1, m_2 & μ_s find maximum possible α (α_{max}) such that the system would remain in equilibrium.

(c) From the results of part (b) deduce an expression for α_{min} such that the system would remain in equilibrium.

hints → * when α is changed, 90° angle at the top is maintained to be constant

* $\tan\theta = \sin\theta/\cos\theta$; $\tan(90° - \theta) = \cot\theta$

<enjoy>