Ph1a - Flipped Section

Problems

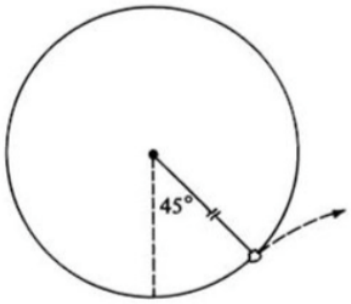
October 7, 2019

1. Sketching trajectories

The position of a particle is given by $\mathbf{r} = A(e^{\alpha t}\,\hat{\mathbf{i}} + e^{-\alpha t}\,\hat{\mathbf{j}})$, where α and A are constants. Find the velocity and speed of the particle, and sketch the trajectory.

2. Swing. Shoot!

A rock is swung on a (massless) string in a circle in the vertical plane. When the string is 45° from the vertical as shown in the figure, it is cut. What trajectory does the rock follow? If the rock is initially moving at 5 m/s, how far does it fly horizontally before falling back to the same height it had when the string was cut? You can ignore air resistance.



3. Slanted Snowfall

Snow is falling vertically at a constant speed of 3 m/s. At what angle from the vertical do the snowflakes appear to be falling as viewed by the driver of a car traveling on a straight, level road with a speed of 60 km/hr?

4. Projectiles and the Firefighter

A firefighter, standing at a distance d from a burning building wants to extinguish a fire which is burning at a height h above the ground. She holds the hose at an angle θ from the horizontal and the net speed of water as it leaves the hose is u. Find a quadratic equation in $(\tan\theta)$ whose solutions(assuming they are real) would be the two possible angles for which the firefighter would be able to extinguish the fire.

5. Canoeing

Tim is capable of paddling his canoe at a velocity, v. Tim wants to land his canoe directly on the other side of a river which is flowing at a speed u. The river has a width d. At what angle θ (with respect to the geodesic *i.e.* the straight line joining the starting and intended final point) must Tim aim his canoe in order to land directly on the other side of the river? How long will it take Tim to land on the other side of the river?

BONUS QUESTION

A butterfly is at position $x = 6$ m at time $t = 0$ s when it spots a boy who is carrying flowers at $x = 0$ m.

a) The boy is moving towards the butterfly at $v = 5$ m/s. On seeing the flowers, the butterfly accelerates towards them at $a = -2$ m/s^2. When and where will the they cross paths? Sketch the motion of the butterfly and the boy by measuring time on the horizontal axis and position on the vertical axis.

b) Suppose, instead, that the boy spots the butterfly at $t = 0$ and starts chasing it at $v = 5$ m/s. The butterfly immediately accelerates away from the boy at a m/s^2. Find a_{max}, the maximum acceleration at which the boy can still catch up with the butterfly. For this acceleration, find the time at which they meet. Show that for smaller values of a, the boy can catch up to the bee twice. Draw a sketch of the position as a function of time for this case.