7) A golf ball of mass \( M \) is struck so that it leaves the tee at an angle of \( \theta \) with respect to the vertical at a speed of \( V_0 \). The horizontal distance to the cup is \( D \) and the green lies a distance \( B \) below the level of the tee. In what follows, you may assume that the total acceleration of the ball is \((g, \text{downward})\). Express your answers to parts a) and b) in terms of the system parameters \( M, \theta, D, B \) and \( V_0 \), along with physical constants, or an appropriate subset thereof, based on the coordinate axes shown in the figure.

OSE  

a) (15) Determine the speed of the ball when it reaches its maximum height above the tee.

\[
\begin{align*}
v_{mx} &= v_{x0} + ax = v_{x0} = V_0 \sin \theta \\
v_{my} &= 0 \\
v_m &= \sqrt{v_{mx}^2 + v_{my}^2} = |v_{mx}| = \frac{V_0 \sin \theta}{\sqrt{1 + \tan^2 \theta}}
\end{align*}
\]

OSE  

c) (30) Derive an expression for the trajectory \( y(x) \), i.e., \( y \) as a function of \( x \).

\[
\begin{align*}
x &= x_0 + v_{x0} t + \frac{1}{2} a_x t^2 \\
y &= y_0 + v_{y0} t + \frac{1}{2} a_y t^2 \\
t &= \frac{x}{v_0 \sin \theta} \\
Y(x) &= \frac{x}{v_0 \sin \theta} - \frac{1}{2} g \left( \frac{x}{v_0 \sin \theta} \right)^2 \\
\end{align*}
\]

c) (10) If \( D = 160 \text{ m} \), \( B = 5 \text{ m} \) and \( \theta = 53.1^\circ \), what initial speed \( V_0 \) must the ball have to go directly into the hole? (Assume that \( g = 10 \text{ m/s}^2 \), and take \( \sin \theta = 4/5 \) and \( \cos \theta = 3/5 \).)

\[
\begin{align*}
y_f &= y(x_f + D) = -B = \left( +D \right) \cot \theta - \frac{1}{2} \left( \frac{g}{v_0^2 \sin^2 \theta} \right) \left( +D \right)^2 \\
\frac{1}{2} \left( \frac{g}{v_0^2 \sin^2 \theta} \right) D^2 &= D \cot \theta + B \\
V_0 &= \sqrt{\frac{gD^2}{2 \sin^2 \theta \left[ D \cot \theta + B \right]}} = \frac{10 \left( 160 \right)^2}{2 \left( \frac{3}{5} \right)^2 \left[ 160 \left( \frac{3}{5} \right) + 5 \right]} = 1600 \\
V_0 &= 40 \text{ m/s}
\end{align*}
\]

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T1 - 3 (W97)