20-R-IM-PT-10

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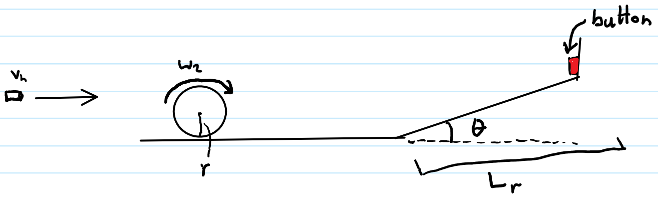
In a game show, a participant comes across a chasm which they must cross in order to reach the finish line. The chasm can be crossed by rolling a solid cylinder 3.5 meters up a ramp with an incline of 20 degrees, where the cylinder would roll into a button which would bring down a bridge . The participant has a gun to roll the cylinder, and has 4 different bullets that to shoot the cylinder. Only one bullet can be chosen and the participant has to pick the bullet with the lowest mass that will still allow them to cross the chasm. If they choose the highest mass pellet, or test multiple pellets, they will be disqualified. The mass of bullet 1 is 3g, 2 is 5.5g, 3 is 7.2 g, and 4 is 9g. Which pellet should they choose?

Assume that gun shoots all pellets with a speed of 900 m/s, the cylinder has a radius of 0.15m and a mass of 0.24 kg. Also assume that the participant can shoot the edge of the cylinder with extremely high accuracy, and there is no slipping of the cylinder or air resistance.



Cons. of Energy

$g = 9.81 m/s$

$KE = PE$

$$\frac{1}{2} m_{c+b} V^2 + \frac{1}{2} I_{G_2} w_2^2 = m_{c+b}\, g\, h$$

$V^2 = (w_2 r)^2$

$$m_{c+b}\, w_2^2 r^2 + \frac{1}{2} m_{c+b}\, w_2^2 r^2 = m_{c+b}\, g h$$

$m_{c+b} = m_c + m_b$

$$w_2^2 = \frac{9.81 \cdot h}{(r^2 + \frac{1}{2} r^2)}$$

$I_{G_2} = \frac{1}{2} m_{c+b}\, r^2$

$h = L_r \cdot \sin(\theta) = 3.5 \cdot \sin(20) = 1.197$

$$w_2 = \left(\frac{9.81 \cdot 1.197}{1.5 \cdot (0.15)^2}\right)$$

$r = 0.15 m$

$w_2 = 342.95$ rad/s

Cons. of momentum

$(H_{sys})_1 = (H_{sys})_2$

$$I_{G_1} w_1 + m_b v \cdot r = I_{G_2} w_2$$

$w_1 = 0$

$$m_b v \cdot r = I_{G_2} w_2$$

$V = 900$ m/s

$m_c = 0.24$ kg

$$m_b \cdot v \cdot r = \frac{1}{2}(m_c + m_b)\, r^2 \cdot w_2$$

$w_2 = 347.95$ rad/s

$r = 0.15$ m

$$m_b \cdot V \cdot r = \frac{1}{2} r^2 \cdot W_2 \cdot m_c + \frac{1}{2} \cdot r^2 \cdot w_2 \cdot m_b$$

$$m_b \cdot v \cdot r - \frac{1}{2} \cdot m_b \cdot r^2 \cdot w_2 = \frac{1}{2} m_c \cdot r^2 \cdot w_2$$

$$m_b = \frac{(\frac{1}{2} m_c \cdot r^2 \cdot w_2)}{(v \cdot r - \frac{1}{2} r^2 \cdot w_2)} = \frac{(\frac{1}{2} \cdot 0.24 \cdot 0.15^2 \cdot 347.95)}{(900 \cdot 0.15 - \frac{1}{2}(0.15)^2 \cdot 347.95)}$$

$m_b = 7.167$ g

$\boxed{\text{The closest mass for the bullet is } 7.2g}$