20-R-IM-PT-10

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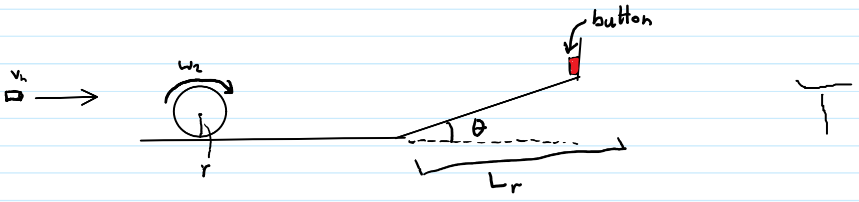
In a game show, a participant must roll a solid cylinder 3.5 meters up a ramp with an incline of 20 degrees, where the cylinder would roll into a button. The participant has a gun to shoot the cylinder, and move it up the ramp. Only one bullet can be chosen and the participant has to pick the bullet with the lowest mass that will still allow them to cross the chasm for the highest score. If they test multiple bullets, they will be disqualified. The mass of bullet 1 is 3g, 2 is 5g, 3 is 8 g, and 4 is 15g. Which bullet should they choose?

Assume that gun shoots all bullets 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

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

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

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

$m_b = 7.167$ g

$\boxed{\text{The closest mass for the bullet is 8 g}}$