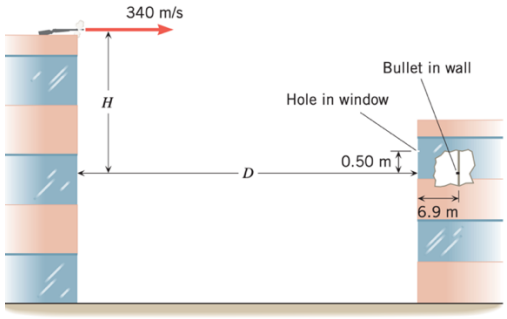
Građevinski i arhitektonski fakultet Osijek
Fizika (PSS-GRAD)

Pismeni ispit

27. 6. 2022.

1. S vrha visoke zgrade ispaljen je hitac. Početna brzina metka je 340 m/s, usporedno s tlom. Metak probije rupu u prozoru druge zgrade i zabije se u zid 0,50 m niže i 6,9 m dalje. Odredite *H* i *D*. Pretpostavite da metak ne usporava dok prolazi kroz prozor. (3.49.; 31 m, 850 m)



SOLUTION Assuming that the direction to the right is positive, we find that the time that the bullet spends in the building is (according to Equation 3.5a)

$$t = \frac{x}{v_{0x}} = \frac{6.9\text{ m}}{340\text{ m/s}} = 0.0203\text{ s}$$

The vertical displacement of the bullet after it enters the building is, taking down as the negative direction, equal to –0.50 m. Therefore, the vertical component of the velocity of the bullet as it passes through the window is, from Equation 3.5b,

$$v_{0y(\text{window})} = \frac{y - \frac{1}{2}a_y t^2}{t} = \frac{y}{t} - \frac{1}{2}a_y t = \frac{-0.50\text{ m}}{0.0203\text{ s}} - \frac{1}{2}(-9.80\text{ m/s}^2)(0.0203\text{ s}) = -24.5\text{ m/s}$$

The vertical displacement of the bullet as it travels between the buildings is (according to Equation 3.6b with $v_{0y} = 0\text{ m/s}$)

$$y = \frac{v_y^2}{2a_y} = \frac{(-24.5\text{ m/s})^2}{2(-9.80\text{ m/s}^2)} = -30.6\text{ m}$$

Therefore, the distance *H* is

$$H = 30.6\text{ m} + 0.50\text{ m} = \boxed{31\text{ m}}$$

The time for the bullet to reach the window, according to Equation 3.4b, is

$$t_1 = \frac{2y}{v_{0y} + v_y} = \frac{2y}{v_y} = \frac{2(-30.6\text{ m})}{(-24.5\text{ m/s})} = 2.50\text{ s}$$

Hence, the distance *D* is given by

$$D = v_{0x}t_1 = (340\text{ m/s})(2.50\text{ s}) = \boxed{850\text{ m}}$$

2. Motocikl jednoliko ubrzava te, u trajanju od 9,00 s, iz mirovanja doseže brzinu 22,0 m/s. Polumjer svakog kotača je 0,280 m. Koliko je kutno ubrzanje kotača? (8.53.; 8,73 rad/s^2)

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53. SSM ***REASONING AND SOLUTION*** From Equation 2.4, the linear acceleration of the motorcycle is

$$a = \frac{v - v_0}{t} = \frac{22.0\ \text{m/s} - 0\ \text{m/s}}{9.00\ \text{s}} = 2.44\ \text{m/s}^2$$

Since the tire rolls without slipping, the linear acceleration equals the tangential acceleration of a point on the outer edge of the tire: $a = a_T$. Solving Equation 8.13 for α gives

$$\alpha = \frac{a_T}{r} = \frac{2.44\ \text{m/s}^2}{0.280\ \text{m}} = \boxed{8.71\ \text{rad/s}^2}$$

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3. Helij se nalazi u posudi volumena 0,010 m^3 pod tlakom od 6,2 · 10^5 Pa. Koliko dugo mora raditi stroj snage 0,25 konjskih snaga (jedna konjska snaga je 746 W) da bi energija koju "proizvede" odgovarala unutrašnjoj energiji spomenutog helija? (14.62; 50 s)

SOLUTION The engine must produce an amount of energy equal to the internal energy $U = \frac{3}{2}nRT$ (Equation 14.7) of the helium, so from Equation (1) we have that

$$t = \frac{\text{Energy}}{\text{Power}} = \frac{U}{\text{Power}} = \frac{\frac{3}{2}nRT}{\text{Power}} \qquad (2)$$

Substituting $PV = nRT$ (Equation 14.1) into Equation (2) yields

$$t = \frac{\frac{3}{2}nRT}{\text{Power}} = \frac{3PV}{2(\text{Power})} \qquad (3)$$

Using the equivalence 1 hp = 746 W in Equation (3), we obtain

$$t = \frac{3PV}{2(\text{Power})} = \frac{3(6.2\times10^5\ \text{Pa})(0.010\ \text{m}^3)}{2(0.25\ \cancel{\text{hp}})\left(\frac{746\ \text{W}}{1\ \cancel{\text{hp}}}\right)} = \boxed{5.0\times10^1\ \text{s}}$$

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4. Otpor između unutrašnjeg i vanjskog dijela membrane biološke stanice je 5,0 · 10^9 Ω. (20.5.;)
   a. Odredite struju kroz membranu ako razlika potencijala između unutrašnjeg i vanjskog dijela membrane iznosi 75 mV. (15 pA)
   b. Ako struju čine natrijevi ioni (q=+e), koliko iona prođe membranu u 0,50 s? (4,7 · 10^7)

SOLUTION

a. The current is

$$I = \frac{V}{R} = \frac{75\times10^{-3}\ \text{V}}{5.0\times10^9\ \Omega} = \boxed{1.5\times10^{-11}\ \text{A}} \qquad (20.2)$$

b. The number of Na^+ ions is the total charge Δq that flows divided by the charge $+e$ on each ion, or $\Delta q / e$. The charge is the product of the current I and the time Δt, according to Equation 20.1, so that

$$\text{Number of Na}^+\text{ ions} = \frac{\Delta q}{e} = \frac{I\,\Delta t}{e} = \frac{(1.5\times10^{-11}\ \text{A})(0.50\ \text{s})}{1.60\times10^{-19}\ \text{C}} = \boxed{4.7\times10^7}$$

5. Dvije konvergentne leće udaljene su 24,00 cm. Žarišna daljina svake leće je 12,00 cm. Predmet je smješten 36,00 cm lijevo od lijeve leće. Izračunajte udaljenost konačne slike s obzirom na desnu leću. (26.67.; 12 cm lijevo)

SOLUTION For the first lens, the object and image distances, $d_{o,1}$ and $d_{i,1}$, are related to the focal length f of the lens by the thin-lens equation

$$\frac{1}{d_{o1}} + \frac{1}{d_{i1}} = \frac{1}{f} \qquad (26.6)$$

Solving this expression for the image distance produced by the first lens, we find that

$$\frac{1}{d_{i1}} = \frac{1}{f} - \frac{1}{d_{o1}} = \frac{1}{12.00\ \text{cm}} - \frac{1}{36.00\ \text{cm}} \quad \text{or} \quad d_{i1} = 18.0\ \text{cm}$$

This image distance indicates that the first image lies between the lenses. Since the lenses are separated by 24.00 cm, the distance between the image produced by the first lens and the second lens is 24.00 cm – 18.0 cm = 6.0 cm. Since the image produced by the first lens acts as the object for the second lens, we have that d_{o2} = 6.0 cm. Applying the thin-lens equation to the second lens gives

$$\frac{1}{d_{i2}} = \frac{1}{f} - \frac{1}{d_{o2}} = \frac{1}{12.00\ \text{cm}} - \frac{1}{6.0\ \text{cm}} \quad \text{or} \quad d_{i2} = \boxed{-12\ \text{cm}}$$

The fact that this image distance is negative means that the final image is virtual and lies to the left of the second lens.