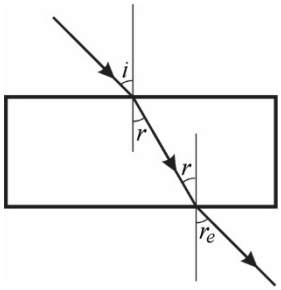
Agenția Națională pentru Curriculum și Evaluare
OLIMPIADA LA *FIZICĂ*
etapa raională/municipală/zonală
21 februarie 2026

BAREM **Clasa a IX-a**

PROBLEMA 1

a) **Total 1,25 p**

pentru raza incidentă	1x0,25p
pentru raza refractată în sticlă	1x0,25p
pentru verticala coborâtă în punctul de incidență	2x0,25p
pentru raza emergentă	1x0,25p

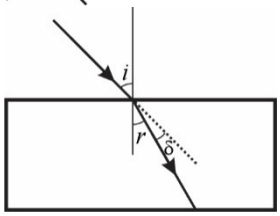


b) **Total: 0,75 p**

$\frac{\sin i}{\sin r} = \frac{n}{n_a}$	1x0,25p
$\sin r = \frac{n_a \sin i}{n}$	1x0,25p
$r = 32{,}77° \approx 33°$	1x0,25p

c) **Total: 0,75 p**

$i = \delta + r$	1x0,25p
$\delta = i - r \approx 27°$	2x0,25p



d) **Total: 0,75 p**

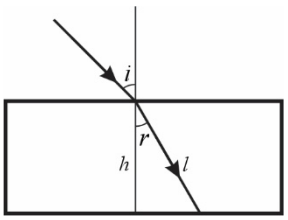
$n = \frac{c}{v}$	1x0,25p
$v = \frac{c}{n} = 1{,}9 \cdot 10^8$ m/s	2x0,25p

e) **Total: 1,25 p**

$\frac{\sin r}{\sin r_e} = \frac{n_a}{n}$	1x0,25p
$\sin r_e = \frac{n \sin r}{n_a}$	1x0,25p
$\sin r = \frac{n_a \sin i}{n}$	1x0,25p
$r_e = i = 60°$	2x0,25p

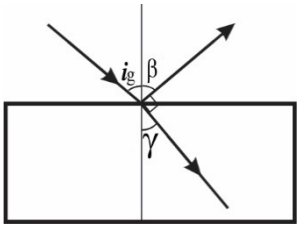
f) **Total: 1,75 p**

$\tau = \frac{l}{v}$	1x0,25p
$l = \frac{h}{\cos r} = \frac{h}{\sqrt{1-\sin^2 r}}$	2x0,25p
$v = \frac{c}{n}$	1x0,25p
$\tau = \frac{hn^2}{c\sqrt{n^2-\sin^2 i}}$	1x0,50p
$\tau = 1{,}9 \cdot 10^{-10}$s	1x0,25p



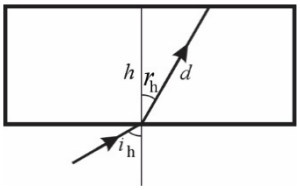
g) **Total: 2,0 p**

$\frac{\sin i_g}{\sin \gamma} = \frac{n}{n_a}$	1x0,25p
$\gamma = 180° - (90° + \beta)$	1x0,25p
$i_g = \beta$	1x0,25p
$\gamma = 90° - i_g$	1x0,25p
$\frac{\sin i_g}{\sin(90°-i_g)} = \frac{n}{1}$	1x0,25p
$\sin(90° - i_g) = \cos\alpha$	1x0,25p
$\mathrm{tg}\, i_g = n$	1x0,25p
$i_g = 58°$	1x0,25p



h) **Total: 1,50 p**

$\frac{h}{d} = \cos r_h = \sqrt{1 - \sin^2 r_h}$	2x0,25p
$\frac{\sin i_h}{\sin r_h} = \frac{n}{1}$	1x0,25p
$i_h = 90°$	1x0,25p
$d = \frac{hn}{\sqrt{n^2-1}}$	1x0,25p
$d = 3{,}8$ cm	1x0,25p



PROBLEMA 2

a) **Total: 1,2 p**

$F = K\frac{m_1 m_2}{r^2}$ 1x0,4p

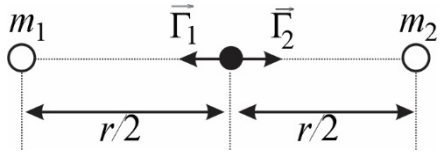
$F \approx 1{,}9 \cdot 10^{-10}$ N 1x0,8p

b) **Total: 1,6 p**

$\Gamma = \Gamma_2 - \Gamma_1$ 1x0,4p

$\Gamma = \frac{4K}{r^2}(m_2 - m_1)$ 1x0,4p

$\Gamma \approx 5{,}6 \cdot 10^{-10}$ N/kg 1x0,8p



c) **Total: 2,4 p**

$\vec{F}_{10} + \vec{F}_{20} = 0$ 1x0,4p

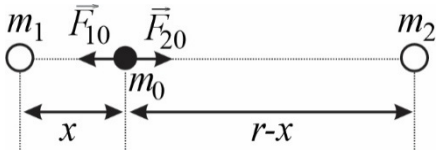
$F_{10} = F_{20}$ 1x0,4p

$K\frac{m_1 m_0}{x^2} = K\frac{m_2 m_0}{(r-x)^2}$ 1x0,4p

$\frac{m_1}{x^2} = \frac{m_2}{(r-x)^2}$ 1x0,4p

$r - x = 2x$ 1x0,4p

$x = \frac{r}{3} = 0{,}40$ m 1x0,4p

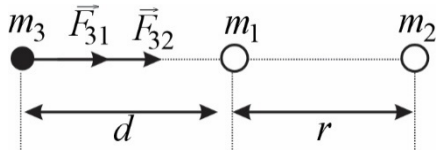


d) **Total: 1,2 p**

$F = F_{23} + F_{13}$ 1x0,4p

$F = K\frac{m_1 m_3}{d^2} + K\frac{m_2 m_3}{(r+d)^2}$ 1x0,4p

$F \approx 1{,}6 \cdot 10^{-9}$ N 1x0,4p



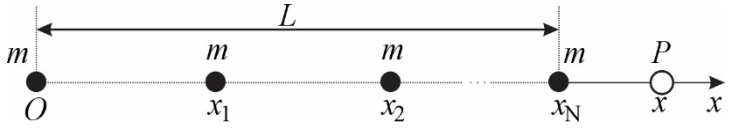
e) **Total: 1,6 p**

$r_i = x - x_i$ 1x0,4p

$\Gamma_i = K\frac{m}{(x-x_i)^2}$ 1x0,4p

$\Gamma = \sum_{i=1}^{N} K\frac{m}{(x-x_i)^2}$ 1x0,4p

$\Gamma = Km\sum_{i=1}^{N}\frac{1}{\left(x - i\frac{L}{N}\right)^2}$ 1x0,4p



f) **Total: 2,0 p**

Dacă $x \gg L$

$x - x_i \approx x$ 1x0,4p

$\Gamma_i \approx K\frac{m}{x^2}$ 1x0,4p

$\Gamma = \sum_{i=1}^{N}\Gamma_i$ 1x0,4p

$\Gamma \approx K\frac{Nm}{x^2}$ 1x0,4p

$\Gamma(x) \approx K\frac{Nm}{x^2}$, $x \gg L$ 1x0,4p

PROBLEMA 3

a) **Total: 0,50 p**

$d_a = \sqrt{d_1^2 + d_2^2}$ 1x0,25p

$d_a = 500$ m 1x0,25p

b) **Total: 1,75 p**

$s_1 = v_1 t$ 1x0,25p

$s_1 = 100$ m 1x0,25p

$s_2 = v_2 t$ 1x0,25p

$s_2 = 200$ m 1x0,25p

$d_b = \sqrt{(d_1 - s_1)^2 + (d_2 - s_2)^2}$ 1x0,25p

$d_b = \sqrt{(d_1 - v_1 t)^2 + (d_2 - v_2 t)^2}$ 1x0,25p

$d_b = 200\sqrt{2}$ m ≈ 283 m 1x0,25p

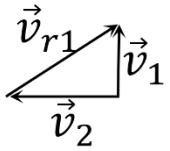
c) **Total: 1,0 p**

pentru diagrama vectorilor 1x0,25p

$\vec{v}_1 = \vec{v}_{r1} + \vec{v}_2$ 1x0,25p

$v_{r1} = \sqrt{v_1^2 + v_2^2}$ 1x0,25p

$v_{r1} = 10\sqrt{5}$ m/s $\approx 22{,}4$ m/s 1x0,25p



d) **Total: 1,75 p**

Metoda 1:

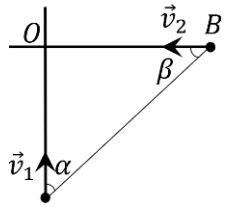
$v_{apr} = v_1 \cos\alpha + v_2 \cos\beta$ 1x0,75p

$\cos\alpha = \frac{d_1}{d_a}$ 1x0,25p

$\cos\beta = \frac{d_2}{d_a}$ 1x0,25p

$v_{apr} = \frac{v_1 d_1 + v_2 d_2}{d_a}$ 1x0,25p

$v_{apr} = 22{,}0$ m/s 1x0,25p



Metoda 2:

$x = d_1 - v_1 \Delta t$ 1x0,1p

$y = d_2 - v_2 \Delta t$ 1x0,1p

d – distanța dintre corpuri

$d = \sqrt{x^2 + y^2}$ 1x0,2p

$d = \sqrt{(d_1 - v_1 \Delta t)^2 + (d_2 - v_2 \Delta t)^2}$ 1x0,2p

$d = \sqrt{d_a^2 - 2d_1 v_1 \Delta t - 2d_2 v_2 \Delta t + v_1^2 \Delta t^2 + v_2^2 \Delta t^2}$ 1x0,2p

Așa cum găsim viteza de apropiere în momentul inițial de timp, vom studia cazul când Δt este foarte mic!

$d = d_a \sqrt{1 - \frac{2d_1 v_1 \Delta t}{d_a^2} - \frac{2d_2 v_2 \Delta t}{d_a^2} + \frac{v_1^2 \Delta t^2}{d_a^2} + \frac{v_2^2 \Delta t^2}{d_a^2}}$ 1x0,2p

$d \approx d_a - \frac{d_1 v_1 \Delta t}{d_a} - \frac{d_2 v_2 \Delta t}{d_a} + \frac{v_1^2 \Delta t^2}{2d_a} + \frac{v_2^2 \Delta t^2}{2d_a}$ 1x0,2p

$-\Delta d = d_a - d = \frac{d_1 v_1 \Delta t}{d_a} + \frac{d_2 v_2 \Delta t}{d_a} - \frac{v_1^2 \Delta t^2}{2d_a^2} - \frac{v_2^2 \Delta t^2}{2d_a^2}$ 1x0,2p

$v_{apr} = -\frac{\Delta d}{\Delta t} \approx \frac{d_1 v_1 + d_2 v_2}{d_a} = 22{,}0$ m/s 1x0,35p

e) **Total: 2,50 p**

Așa cum după intersecție, la un moment dat, viteza de apropiere trece în viteză de îndepărtare, viteza de apropiere minimă este egală cu zero, în momentul tranziției, când distanța dintre corpuri este minimă.

$v_{\min} = 0$ 1x0,25p

$d = \sqrt{(d_1 - v_1 t_e)^2 + (d_2 - v_2 t_e)^2}$ 1x0,25p

$d = d_{\min} \Rightarrow d^2 = \min$ 1x0,25p

$f(t_e) = (v_1^2 + v_2^2) t_e^2 - 2(d_1 v_1 + d_2 v_2) t_e + (d_1^2 + d_2^2)$ 1x0,25p

$t_e = -\frac{b}{2a} = \frac{d_1 v_1 + d_2 v_2}{v_1^2 + v_2^2}$ 2x0,25p

$t_e = 22{,}0$ s 1x0,25p

$\Delta = -4(d_1 v_2 - d_2 v_1)^2$ 1x0,25p

$d_e = \sqrt{-\frac{\Delta}{4a}} = \frac{d_1 v_2 - d_2 v_1}{\sqrt{v_1^2 + v_2^2}}$ 1x0,25p

$d_e = 89{,}4$ m 1x0,25p

f) **Total: 0,50 p**

$d_{\min} = d_e = 89{,}4$ m 2x0,25p

g) **Total: 2,0 p**

Fie punctul B', poziția unde corpul 2 recepționează semnalul.

$BB' = v_2 \tau$ 1x0,25p

$AB' = v_s \tau$ 1x0,25p

$OB' = d_2 - BB'$ 1x0,25p

$AB'^2 = OA^2 + OB'^2$ 1x0,25p

$\tau^2 + \frac{2v_2 d_2}{v_s^2 - v_2^2}\tau - \frac{d_a^2}{v_s^2 - v_2^2} = 0$ 1x0,25p

$\tau_{1(2)} = -b \pm \sqrt{b^2 + c}$ 1x0,25p

$\tau = \sqrt{b^2 + c} - b$ 1x0,25p

unde: $b = \frac{v_2 d_2}{v_s^2 - v_2^2}$, $c = \frac{d_a^2}{v_s^2 - v_2^2}$

$\tau = 1{,}41$ s 1x0,25p