④ (A) $F_{spring} = kx$ $\quad F_{friction} = \mu mg$

To move $F_{spring} \geq F_{friction}$

$\Leftrightarrow kx \geq \mu mg$

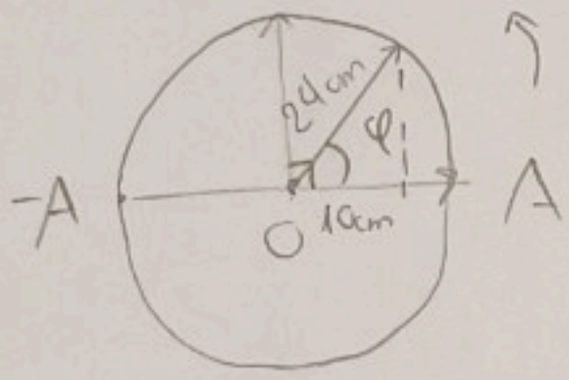
$\Leftrightarrow k = \frac{\mu mg}{x} = \frac{0.32 \times 2 \times 9.81}{2.2} = 2.8538$ N/m

(B) $\mu mgd = \frac{1}{2}(kx^2 - kx'^2)$ (1)

$kx'^2 = \mu mg \Leftrightarrow x' \approx 1,2073m$

(1) $\Rightarrow d \approx 1,4m$

⑤ $0,1m = 10cm$



$\cos\varphi = \frac{10}{24} \Leftrightarrow \varphi = \arccos\left(\frac{10}{24}\right)$

$\omega = 2\pi f = \frac{26}{25}\pi$

Harmonic oscillation equation, with x as displacement

$x = 24\cos\left(\frac{26}{25}\pi t + \arccos\frac{10}{24}\right)$ cm

$x = 10$ cm

$\Leftrightarrow 10 = 24\cos\left(\frac{26}{25}\pi t + \arccos\frac{10}{24}\right)$

$\Leftrightarrow \begin{cases} t = \frac{25}{13}k \\ t = 1.22462 + \frac{25}{13}k \end{cases}, k \in \mathbb{Z}$

$v = x' = -\frac{26}{25}\pi \times 24\sin\left(\frac{26}{25}\pi t + \arccos\frac{10}{24}\right)$

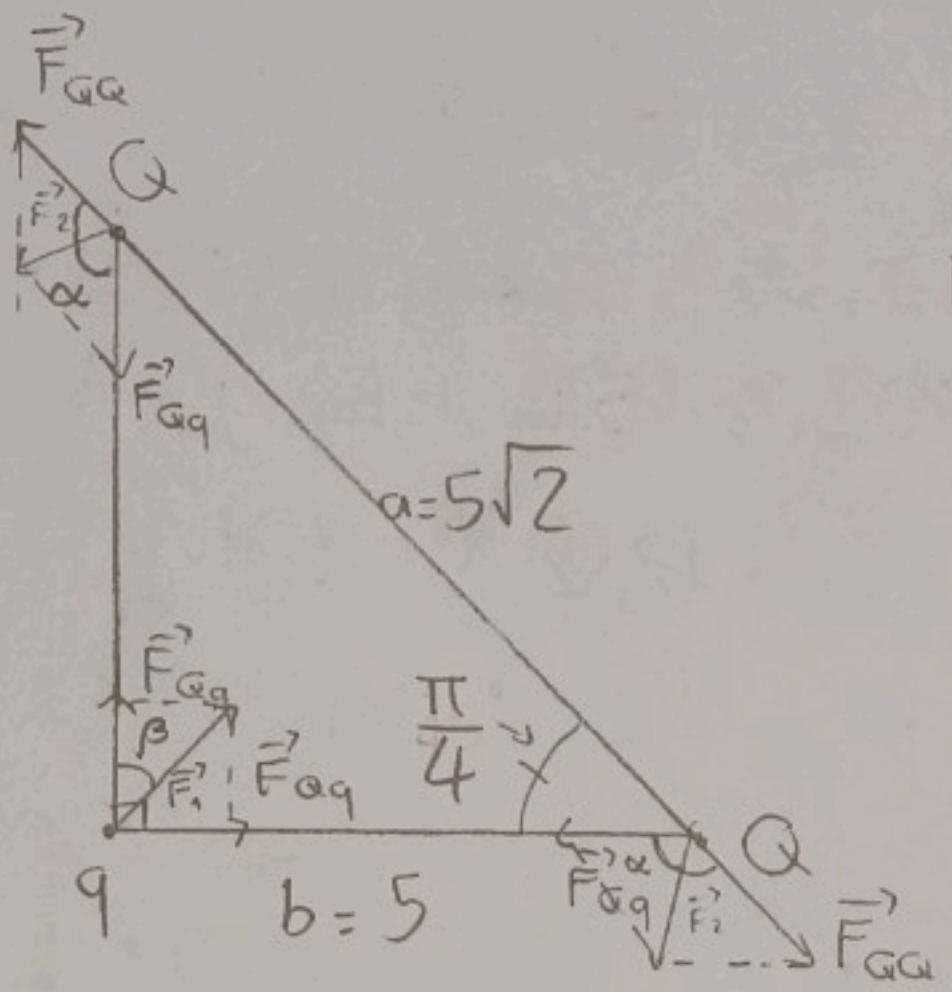
$= 71.28 cm/s$

$a = v' = \left(\frac{26}{25}\pi\right)^2 \times 24\cos\left(\frac{26}{25}\pi t + \arccos\frac{10}{24} + \pi\right)$

$= 106,75 cm/s^2$

$E = \frac{1}{2}mv^2 = 0,13048 J$

(3)



$$F_{QQ} = k\frac{Q^2}{a^2} = 4.05E-04\ N$$

$$F_{Qq} = k\frac{Qq}{b^2} = 5.4E-04\ N$$

$$F_1 = \sqrt{2F_{Qq}^2} = 7.368E-04N$$

$$\alpha = \pi - \frac{\pi}{4} = \frac{3\pi}{4}\ rad$$

$$F_2 = \sqrt{F_{QQ}^2 + F_{Qq}^2 + 2.F_{QQ}F_{Qq}\cos\alpha}$$

$$= 3.825E-04N$$

$$\beta = \frac{\pi}{2} \div 2 = \frac{\pi}{4}\ rad$$

(1) a) $\frac{P_1}{T_1} = \frac{P_2}{T_2} \Leftrightarrow T_2 = \frac{P_2 . T_1}{P_1} = \frac{2.2 \times (43 + 273.15)}{2.5}$

$$= 278.212K$$

$$\frac{P_2}{T_2} = \frac{P_3}{T_{ambient}} \Leftrightarrow P_3 = \frac{P_2 . T_{ambient}}{T_2} = \frac{2.2 \times (-5 + 273.15)}{278.212}$$

$$= \boxed{2.12\ bars}$$

b) $\frac{P_1}{T_1} = \frac{P'}{T'_{ambient}} \Leftrightarrow P' = \frac{P_1 . T'_{ambient}}{T_1} = \frac{2.5 \times (-7 + 273.15)}{43 + 273.15}$

$$= \boxed{2.105\ bars}$$

c) $\frac{P_2 V}{T_2} = \frac{P_3 V'}{T_{ambient}} \Leftrightarrow V = 22.7l \quad \Delta V = 93 - 22.7$

$$= 20.3l$$

$P' = 2.105\ bars$, $T'_{ambient} = -7°C$ ← $P_1 = 2.5\ bars$, $T_1 = 43°C$ → $P_2 = 2.2\ bars$, $T_2 = 278.212K$ → $P_3 = 2.12\ bars$, $T_{ambient} = -5°C$

$$\frac{P_2 \Delta V}{T_2} = \frac{P_{air}\Delta V'}{T_{ambient}} \Leftrightarrow V' = \boxed{43,923l}$$

(2) a) $F_N = W \Leftrightarrow \rho_w V_{in} g = \rho_{ice} V_w g$

$$\Leftrightarrow \frac{V_{in}}{V_w} = \frac{\rho_{ice}}{\rho_w} = \frac{\frac{777}{883} \times 1000}{999.87}$$

$$\rightarrow \frac{V_{in}}{V_w} = 0.88$$

$$\%V_{out} = (1 - 0.88) \times 100$$

$$= 12\%$$

b) $V_{ice} = \frac{m_1}{m_2} \times 1000 = 847.3$

$$V_{air} = 883 - 847.3$$

$$= 35.68l$$