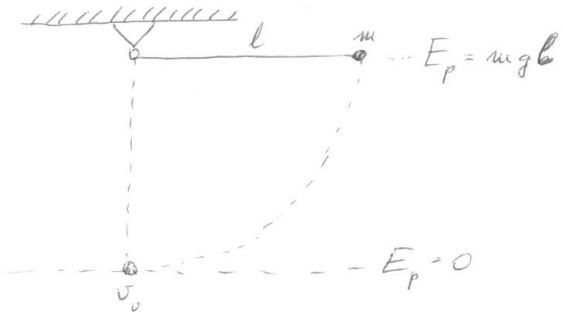
Physics Entrance Exam – DETAILED SOLVING KEY

Part I – Exercises, problems

1.) $m = 0.2\ kg$, $g = 10\ \frac{m}{s^2}$, $L = 0.8\ m$



a. v_v =?

$E_{pot} = E_{kin}$

$mgL = \frac{1}{2}m{v_v}^2$

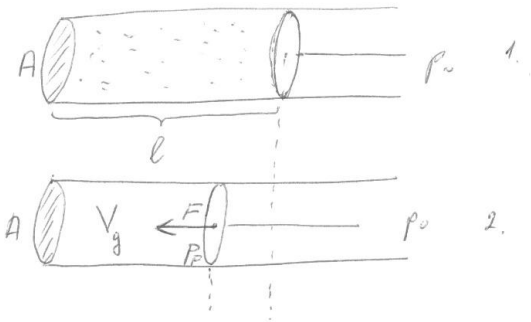
${2gL} = {v_v}^2$

$v_v = \sqrt{2gL} = \sqrt{2 \cdot 10\frac{m}{s^2} \cdot 0.8m} = \sqrt{16\frac{m^2}{s^2}} = \mathbf{4\ \frac{m}{s}}$

b. a_{cp} =?

$a_{cp} = \frac{{v_v}^2}{L} = \frac{16\ \frac{m^2}{s^2}}{0.8\ m} = \mathbf{20\ \frac{m}{s^2}}$

2.) $A = 1\ dm^2 = 0.01\ m^2$, $l = 7\ dm = 0.7\ m$, $F = 400\ N$, $T = constant$, $p_0 = 10^5\ Pa$



a. p_F =?

$$p_F = \frac{F}{A} = \frac{400\ N}{0.01\ m^2} = 40000\ \frac{N}{m^2} (= Pa) = \mathbf{4 \cdot 10^4\ \frac{N}{m^2} (= Pa)}$$

b. p_g =?

$$p_g = p_F + p_0 = 4 \cdot 10^4\ \frac{N}{m^2} (= Pa) + 10^5\ Pa \left(\frac{N}{m^2}\right) = 140000\ \frac{N}{m^2} (= Pa)$$
$$= \mathbf{1.4 \cdot 10^5\ \frac{N}{m^2} (Pa)}$$

c. V_g =?

$T = constant \Rightarrow Boyle's\ law: p_1 \cdot V_1 = p_2 \cdot V_2$
$p_1 = p_0$
$p_2 = p_F + p_0 = p_g$
$V_2 = V_g$
so

$$p_0 \cdot V_1 = p_g \cdot V_g$$

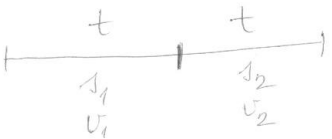
$$V_g = \frac{p_0 \cdot V_1}{p_g} = \frac{p_0 \cdot A \cdot l}{p_g} = \frac{10^5\ Pa \cdot 0.01\ m^2 \cdot 0.7\ m}{1.4 \cdot 10^5\ Pa} = \mathbf{0.005\ m^3 = 5 dm^3}$$

3.) $v_1 = 80\ \frac{km}{h}$, $v_2 = 40\ \frac{km}{h}$

a. v_{av} =?

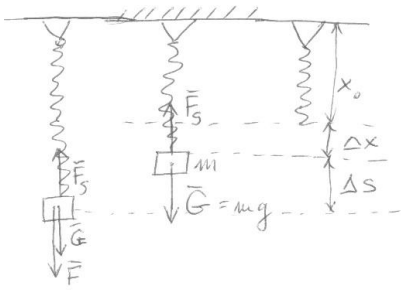
$$v_{av} = \frac{\sum s}{\sum t} = \frac{s + s}{t_1 + t_2} = \frac{2s}{\frac{s}{v_1} + \frac{s}{v_2}} = \frac{2s}{\frac{sv_2 + sv_1}{v_1 \cdot v_2}} = \frac{2sv_1 \cdot v_2}{s \cdot (v_1 + v_2)} = \frac{2 \cdot 80\frac{km}{h} \cdot 40\frac{km}{h}}{80\frac{km}{h} + 40\frac{km}{h}}$$
$$= \frac{6400\frac{km^2}{h^2}}{120\ \frac{km}{h}} = \mathbf{53.33\ \frac{km}{h}}$$

b. v_{av} =?



$$v_{av} = \frac{\sum s}{\sum t} = \frac{s_1 + s_2}{t + t} = \frac{v_1 \cdot t + v_2 \cdot t}{2t} = \frac{v_1 + v_2}{2} = \frac{80\ \frac{km}{h} + 40\ \frac{km}{h}}{2} = \mathbf{60\ \frac{km}{h}}$$

4.) $m = 2\ kg, \Delta x = 10\ cm = 0.1\ m, g = 10\frac{m}{s^2}$



a. D =?

equilibrium position: $F_s = G$

$$D \cdot \Delta x = mg$$

$$D = \frac{mg}{\Delta x} = \frac{2\ kg \cdot 10\frac{m}{s^2}}{0.1\ m} = \mathbf{200\ \frac{N}{m}}$$

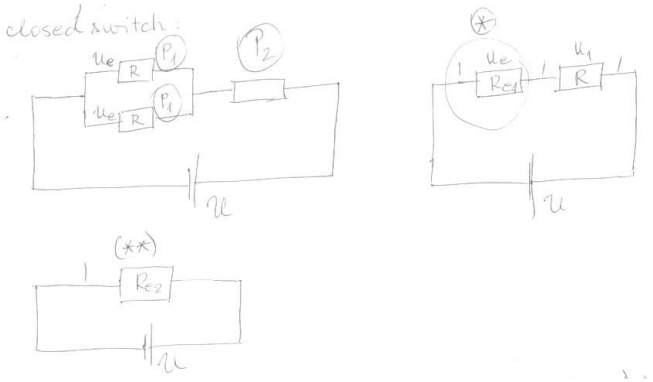
b. W =?

$$F = D \cdot \Delta s = 200\ \frac{N}{m} \cdot 0.05\ m = 10\ N$$

$$W = F \cdot \Delta s = 10\ N \cdot 0.05\ m = 0.5\ Nm = \mathbf{0.5\ J}$$

5.) $U = 5\ V, R = 10\ \Omega$

a. closed switch:



$$R_{e2} = \frac{R}{2} + R = \frac{3}{2}R$$

(**) for the mostly siplified electric circuit: $I = \frac{U}{R_{e2}} = \frac{5\,V}{\frac{3}{2}\cdot 10\,\Omega} = \frac{1}{3}A$

(*) for the mid-simplified electric circuit: $U_e = IR_{e1} = I\frac{R}{2} = \frac{1}{3}\,A \cdot 5\,\Omega = \frac{5}{3}\,V$

doube check: $U_1 = RI = 10\,\Omega \cdot \frac{1}{3}\,A = \frac{10}{3}\,V$ the total voltage: $U = U_e + U_1 = \frac{5}{3}V + \frac{10}{3}V = 5\,V$, so, it is good.

the power dissipated by one resistor in the parallel arm of the system:

$$P_1 = \frac{{U_e}^2}{R} = \frac{(\frac{5}{3}V)^2}{10\,\Omega} = \mathbf{\frac{5}{18}\,W = 0.28\,W}$$

the power dissipated by one resistor in the serial arm of the system:

$$P_2 = \frac{{U_1}^2}{R} = \frac{(\frac{10}{3}V)^2}{10\,\Omega} = \frac{10}{9}\,W = \mathbf{\frac{20}{18}\,W = 1.11\,W}$$

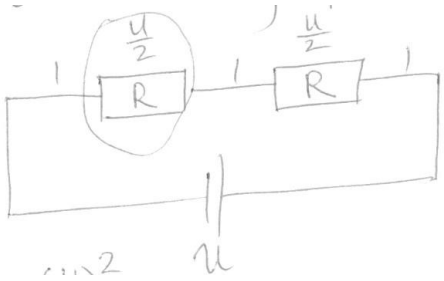
double check:

$$\sum P = P_1 + P_1 + P_2 = \frac{5}{18}\,W + \frac{5}{18}\,W + \frac{20}{18}\,W = \frac{30}{18}\,W = 1.67\,W$$

the power for the whole circuit:

$$P_{closed} = \frac{U^2}{R_{e2}} = \frac{U^2}{\frac{3}{2}R} = \frac{(5V)^2}{\frac{3}{2}\cdot 10\,\Omega} = 1.67\,W = \sum P \text{ correct.}$$

b. opened switch:



$$P_3 = \frac{(\frac{U}{2})^2}{R} = \frac{(\frac{5V}{2})^2}{10\,\Omega} = \mathbf{\frac{5}{8}\,W = 0.625\,W}$$

Part II – Multiple choice test

1.) **b)**

2.) **b)**

3.) $R = 37.5\Omega, U = 12\ V, I = \frac{U}{R} = \frac{12\ V}{37.5\ \Omega} = 0.32\ A$ … correct answer: **a)**

4.) serial case: $R_e = 2R, U, \Rightarrow\ P_{serial} = \frac{U^2}{2R}$, Parallel case: $R_e = \frac{R}{2}, U, \Rightarrow\ P_{parallel} = \frac{U^2}{\frac{R}{2}} = \frac{2U^2}{R}$

$P_{serial} = \frac{U^2}{2R}\ <\ P_{parallel} = \frac{U^2}{\frac{R}{2}} = \frac{2U^2}{R}$ correct answer: **b)**

5.) $F_1 = 50\ N, \Delta x = 10\ cm = 0.1\ m,\ \ F_1 = D \cdot \Delta x\ \ \Rightarrow D = \frac{F_1}{\Delta x} = \frac{50\ N}{0.1\ m} = 500\ \frac{N}{m}$,

$2F = D \cdot \Delta y,\ \ \Rightarrow\ \Delta y = \frac{2F}{D} = \frac{2 \cdot 100\ N}{500\ \frac{N}{m}} = 0.4\ m = 40\ cm$ correct answer: **c)**

6.) ${}^{236}_{92}U,\ \ {}^{A}_{Z}U,\ \ A = Z + N$, (relative atomic mass = number of protons + number of neutrons)

$N = A - Z = 236 - 92 = 144$, correct answer: **a)**

7.) **c)**

8.) **c)**

9.) **a)**

10.) **a)**