6.

a) $B = 15\,mT = 15 \cdot 10^{-3} T$

$q = q_p = 1{,}6 \cdot 10^{-19} C$

$m_p = 1{,}67 \cdot 10^{-27} kg$

$v = 2 \cdot 10^6 m/s$

$r = ?$

$$r = \frac{mv}{|q|B}$$

b)

$q = 1{,}6 \cdot 10^{-19} C$

$B = 15\,mT = 15 \cdot 10^{-3} T$

$r = 10\,cm = 0{,}1\,m$

$p = ?$

$$p = mv \quad ; \quad r = \frac{mv}{|q|B} = \frac{p}{|q|B}$$

$$p = |q| r B$$

7. $B = 0{,}02\,T$

a) $q = q_e = +1{,}6 \cdot 10^{-19} C$

$r = 1\,cm = 0{,}01\,m$

$m_e = 9{,}1 \cdot 10^{-31} kg$

$E_{xe} = ?$

$1\,eV = 1{,}6 \cdot 10^{-19} J \Rightarrow$

$1\,J = \frac{1}{1{,}6 \cdot 10^{-19}}\,eV$

$$E_x = \frac{mv^2}{2} \quad ;$$

$$r = \frac{mv}{|q| \cdot B} \Rightarrow \quad v = \frac{|q| r B}{m} \Rightarrow$$

$$E_x = \frac{m}{2} \cdot \left( \frac{|q| r B}{m} \right)^2 = \frac{(|q| r B)^2}{2m}$$

8 b) $E_k = 1keV = 1{,}6 \cdot 10^{-16} J$

$r = 1mm = 10^{-3} m$

---

$F = ?$

po krugu $\Rightarrow \vec{v} \perp \vec{B}$ $(\sphericalangle(\vec{v}, \vec{B}) = 90°)$

$$F_e = |2| v B \underbrace{\sin \sphericalangle(\vec{v}, \vec{B})}_{1} | = |2| v B$$

(koristimo se rješenjem iz prvog dijela zadatka pod (a))

$$E_k = \frac{(|2| v B)^2}{2m} = \Big/ \qquad E_k = \frac{m v^2}{2}$$

$$r = \frac{m v}{|2| B} \Big/ \cdot \frac{2v}{2v}$$

$$r = \frac{2 m v^2}{2 |2| B v} = \frac{E_k}{} = \frac{2 E_k}{|2| B v} \Rightarrow$$

$$|2| B v = \frac{2 E_k}{r} \Rightarrow$$

$$F_e = |2| v B = \frac{2 E_k}{r} \quad ; \quad \boxed{F_e = \frac{2 E_k}{r}}$$

8. $q_e = -1{,}6 \cdot 10^{-19}\,C$
$m_e = 9{,}1 \cdot 10^{-31}\,kg$
$B = 0{,}2\,T$

$\vec{v} \perp \vec{B}$ (po kružnici)

$\nu = ?$

$\vec{F}_e \perp \vec{v}, \vec{B} \Rightarrow \vec{a} = \vec{a}_{cp}$ ($\vec{a}_t = \vec{0}$, nema promjene inteziteta brzine) pa se kreće ravnomjerno kružno

$v = \frac{s}{t}$ ; za $t = T \Rightarrow s = 2r\pi$

$v = \frac{2r\pi}{T}$ ; $\frac{1}{T} = \nu \Rightarrow v = 2r\pi\nu$

$\nu = \frac{v}{2r\pi}$ ; poluprečnik putanje dat je sa $r = \frac{mv}{|q|B}$

$\nu = \frac{v}{2\pi \cdot \frac{mv}{|q|B}} = \frac{|q|B}{2\pi m}$

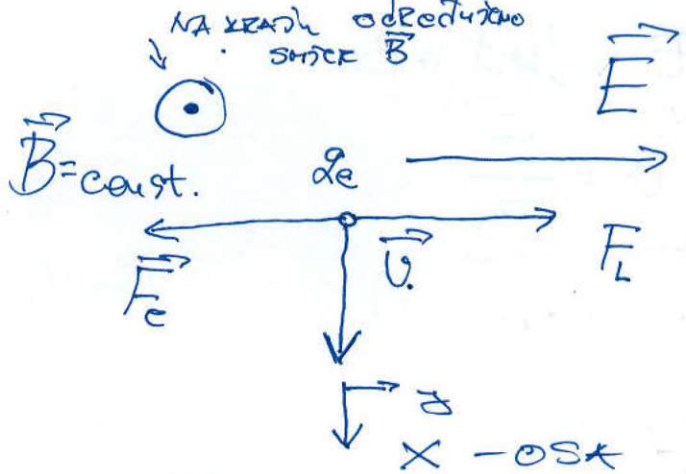
$$\boxed{\nu = \frac{|q|B}{2\pi m}}$$

9. $\vec{v}_e \perp \vec{E} \perp \vec{B}$

$E = 10^4 \frac{V}{m}$

$B = 0{,}02\,T$

$v = ?$




Najbitnija je slika!!!

Da bi se elektron kretao pravolinijski zbir sila duž pravca normalnog na $\vec{v}$ mora biti $\vec{F}_y = \vec{0}$

Na elektron djeluju električno i magnetno polje silama $\vec{F}_e$ i $\vec{F}_L$ (ito duž y osi)

$$\vec{F}_3 = \vec{F}_e + \vec{F}_L = \vec{0}$$

$$\vec{F}_e = -\vec{F}_L$$ (suprotnog su smjera pa pažljivo treba odabrati smjer vektora magnetne indukcije na slici)

① $F_e = F_L$

$\vec{F}_e = q_e \vec{E} \Rightarrow \vec{F}, \vec{E}$ isti pravac, suprotan smjer zbog $q_e < 0$

② $\boxed{F_e = |q_e| \cdot E}$

$F_L = |q v B \sin \sphericalangle(\vec{v}, \vec{B})|$

$\sphericalangle(\vec{v}, \vec{B}) = 90° \Rightarrow \sin 90° = 1$

③ $\boxed{F_e = |q| v B}$

2, 3 u 1

$|q_e| E = |q_e| v B$

$$\boxed{v = \frac{E}{B}}$$

10. $q = 1,6 \cdot 10^{-19} C$ (jednostruko ionizovan)

$v_1 = v_0 = 0$

a) $U = 800 V$

$B = const.$

$r_1 = 7,63 cm = 0,0763 m$

$r_2 = 8,05 cm = 0,0805 m$

$B = 0,32 T$

$m = ?$

Električno polje ubrzava čestice ($a = const.$)

$\vec{F_e} = q\vec{E} \Rightarrow F_e = |q|E \quad ; \quad \frac{U}{s} = E \quad ; \quad a = \frac{v - v_0}{t}, \; s = v_0 t + \frac{at^2}{2}$

ili pomoću rada električnog polja

$A = |q|U \quad ; \quad A = \Delta E_k = E_{k2} - \cancel{E_{k1}}^{0}$

$E_k = \frac{mv^2}{2}$

$A = \frac{mv_2^2}{2} \equiv \frac{mv^2}{2} \Rightarrow \frac{mv^2}{2} = |q|U$

$v = \sqrt{\frac{2|q|U}{m}}$

$r = \frac{mv}{|q|B} \Rightarrow r = \frac{m}{|q| \cdot B}\sqrt{\frac{2|q|U}{m}}$

$r = \frac{1}{B}\sqrt{\frac{2mU}{|q|}} \Big|^2$

$$\boxed{m = \frac{r^2 B^2 |q|}{2U}}$$

b)

$q_1 = q_2 = q$

$\vec{v} \perp \vec{B}$

$m_1 = 2 \cdot 10^{-26}\,kg$

$r_1 = 4\,cm = 0{,}04\,m$

$r_2 = 6\,cm = 0{,}06\,m$

---

$m_2 = ?$

Ubrzana istim naponom

$A = \Delta E_k = qU$

$E_{k_2} - E_{k_1}^{\nearrow 0} = qU$

$m \cdot \left| \frac{mv^2}{2} = qU = const \right.$

$(q, U = const)$

$$r_1 = \frac{m_1 v_1}{|q|B}$$

$$r_2 = \frac{m_2 v_2}{|q|B}$$

$$\frac{(mv)^2}{2} = mqU$$

$$mv = \sqrt{2mqU}$$

$$r_1 = \frac{\sqrt{2m_1 qU}}{|q|B}$$

$$r_2 = \frac{\sqrt{2m_2 qU}}{|q|B}$$

$$\Rightarrow \frac{r_2}{r_1} = \frac{\frac{\sqrt{2m_2 qU}}{|q|B}}{\frac{\sqrt{2m_1 qU}}{|q|B}}$$

$$\frac{r_2}{r_1} = \sqrt{\frac{m_2}{m_1}} \quad \Big/^2$$

$$\boxed{m_2 = m_1 \left(\frac{r_2}{r_1}\right)^2}$$

12.

a) $m_p = 1{,}67 \cdot 10^{-27}\,kg$

$Q_p = 1{,}6 \cdot 10^{-19}\,C$

$r_d = 0{,}6\,m$

$E_{k\,max} = 4\,MeV$

$B = ?$

Putanja elektrona je kružnica koja je najvećeg poluprečnika za $r = r_d$

$$r = \frac{m_p v}{|Q_p| B} = \frac{m_p v}{Q_p B} \quad / \quad E_k = \frac{m v^2}{2}, \quad r = r_d, \quad E_k = E_{k\,max}$$

$$2E_{k\,max} = m_p v^2 \Rightarrow v = \sqrt{\frac{2E_{k\,max}}{m_p}}$$

$$r_d = \frac{m_p}{Q_p B} \cdot \sqrt{\frac{2E_{k\,max}}{m_p}} = \frac{\sqrt{2 m_p E_{k\,max}}}{Q_p \cdot B}$$

$$\boxed{B = \frac{\sqrt{2 m_p E_{k\,max}}}{Q_p r_d}}$$

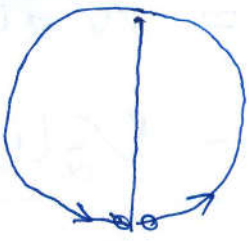
b) ~~$E_{k\,max} = ?$~~

$m = 3{,}32 \cdot 10^{-27}\,kg$

$Q = 1{,}6 \cdot 10^{-19}\,C$

$r_d = r_{max} = 50\,cm = 0{,}5\,m$

$\nu = 15\,MHz = 15 \cdot 10^6\,Hz$



$s = 6$ (obim)

$t = T$

$E_{k\,max} = ?$

$v = const.$ $(a_t = 0)$

$$v = \frac{s}{t} = \frac{2r\pi}{T} = 2r\pi \cdot \nu$$

$$E_{k\,max} = \frac{m v^2}{2}, \quad r = r_d$$

$$E_{kmax} = \frac{m}{2} \cdot v^2 = \frac{m}{2} \cdot (2r_0\pi \cdot \nu)^2$$

$$\boxed{E_{kmax} = 2m(\pi r_0 \cdot \nu)^2}$$

13. $U = 30kV = 3 \cdot 10^4 V$

$E_{kmax} = 10MeV$

$N = ?$

$(q = e_p, \; m = m_p)$

$E_{k_1} = 0J$ (na početku proton mirovao)

$A = \Delta E_k = E_{k_2} - E_{k_1} = qU$ (1. prolaz)

sledeći prolaz (obrtaj)

$E_{k_3} - E_{k_2} = qU$ (2. prolaz)

$E_{k_4} - E_{k_3} = qU$ (3. prolaz)

!

$E_{k_{N+1}} - E_{k_N} = qU$ (N - prolaz)

(indeksu su povećani za 1 jer bez prolaza nosi indeks 1.)

Sabiranjem redukcijom

$(E_{k_2} - E_{k_2}, E_{k_3} - E_{k_3} \ldots)$

i dobijamo

$E_{k_{N+1}} = NqU$ ; $E_{k_{N+1}} = E_{kmax}$

$E_{kmax} = NqU$

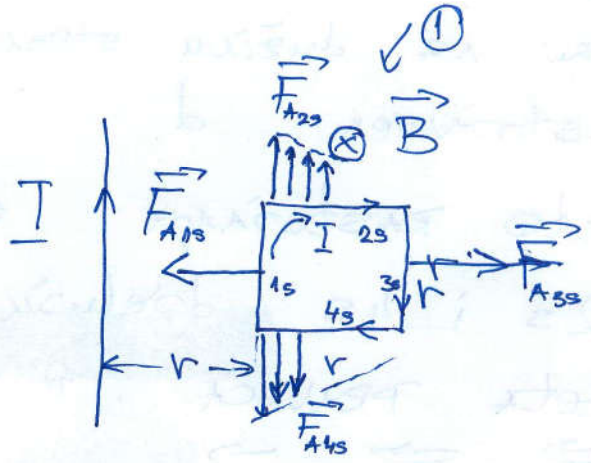
$$\boxed{N = \frac{E_{kmax}}{qU}}$$

15.

a)

$I = 10\,A$

$F_R = ?$




Ram se nalazi u ① magnetnom polju (prvo ovo odredimo) stalnog provodnika ($\vec{B}$ pravilom desne ruke)

$$\vec{F}_R = \vec{F}_{1s} + \vec{F}_{2s} + \vec{F}_{3s} + \vec{F}_{4s}$$

Na provodnike rama ~~zbog protiranja~~ djeluje Amperova sila $F_A = I\ell B|\sin\measuredangle(\vec{\ell},\vec{B})|$

$\measuredangle(\vec{\ell},\vec{B}) = 90°$ (sa slike) $\Rightarrow$

$\sin\measuredangle(\vec{\ell},\vec{B}) = 1 \Rightarrow$

$$\boxed{F_A = I\ell B} \qquad B = \mu_0 \frac{I}{2\pi d}$$

Gdje je d najkraća udaljenost posmatrane tačke od str. provodnika

1s $F_{A13} = I \cdot r \cdot B_{1s}$ ; $B_{1s} = \mu_0 \frac{I}{2\pi r} = const.$

$F_{A13} = I \cdot r \cdot \mu_0 \frac{I}{2\pi r} = \mu_0 \frac{I^2}{2\pi}$

$$\boxed{F_{A13} = \mu_0 \frac{I^2}{2\pi}}$$

odredimo pravac i smjer Amperove sile (pravilo lijeve ruke ili desnog triedra)

2s, 4s NA DRUGU STRANICU DJELUJE PROMJENLJIVA SILA (U ODNOSU NA DUŽINU STRANICE) JER SE B MIJENJA SA RASTOJANJEM d

ZA ISTO RASTOJANJE OD PRAVOLINIJSKOG PR. STR. 2s i 4s DJELUJU AMPEROVE SILE ISTIH INTENZITETA PRAVACA, A SUPROTNIH SMJEROVA PA JE $\vec{F}_{2s} + \vec{F}_{4s} = \vec{0}$

Bs.

$$F_{A3s} = I \cdot r B_{3s} \quad ; \quad B_{3s} = \mu_0 \frac{I}{2\pi \cdot 2r}$$

$$\boxed{F_{A3s} = \mu_0 \frac{I^2}{4\pi}}$$

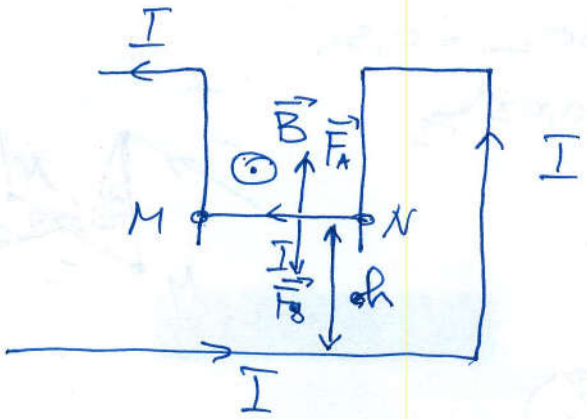
$$\vec{F}_A = \vec{F}_{1s} + \vec{F}_{2s} + \vec{F}_{3s} + \vec{F}_{4s} = \vec{F}_{1s} + \vec{F}_{2s}$$

($\vec{F}_{1s}, \vec{F}_{2s}$ kolinearni vektori suprotnih smjerova)

$$F_A = F_{1s} - F_{2s} = \mu_0 \frac{I^2}{2\pi} - \mu_0 \frac{I^2}{4\pi} = \frac{\mu_0 I^2}{4\pi}(2-1)$$

$$\boxed{F_A = \frac{\mu_0 I^2}{4\pi}}$$

b)




$h = 36\ mm$

$\frac{m}{l} = 2\frac{g}{m} = 2 \cdot 10^{-3}\frac{kg}{m}$

$MN = l$

$I = ?$

Na provodnik MN djeluje gravitacijska i Amperova sila (od donjeg pravolinijskog provodnika)

$\vec{B}_d$ - pravilom desne ruke, ....

$$B_d = \mu_0 \frac{I}{2\pi h}$$

$$F_A = I l B_d = \mu_0 \frac{I^2 l}{2\pi h}$$

$$\vec{F} = m\vec{a} = \vec{0}$$ Pošto se provodnik MN ne kreće

$$\vec{F}_g + \vec{F}_A = \vec{0} \Rightarrow \vec{F}_g = -\vec{F}_A \Rightarrow F_g = F_A$$

$$F_g = mg \quad ; \quad F_A = \mu_0 \frac{I^2 l}{2\pi h}$$

$$mg = \mu_0 \frac{I^2 l}{2\pi h} \Rightarrow I = \sqrt{\frac{2\pi g h \frac{m}{l}}{\mu_0}}$$

$$\boxed{I = \sqrt{\frac{2\pi g}{\mu_0} h \frac{m}{l}}}$$

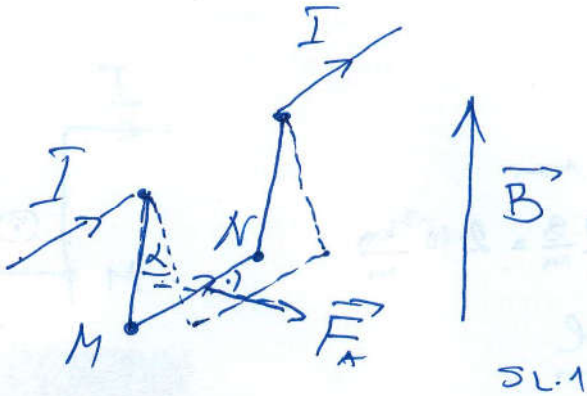
16.

b) $l = MN = 30\,cm = 0{,}3\,m$

$m = 30\,g = 0{,}03\,kg$

$I = 1\,A$

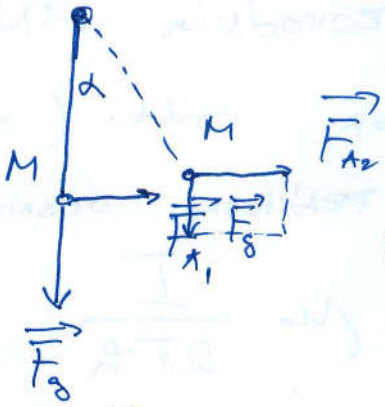
$B = 0{,}5\,T$




Sl. 1.

$$\vec{F}_A = I(\vec{l} \times \vec{B})$$

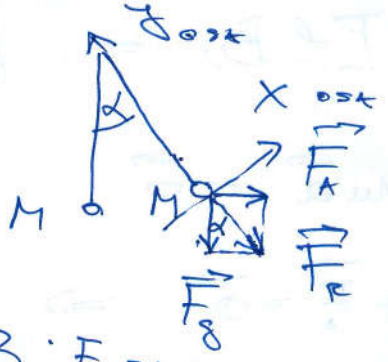
$\vec{F}_A \perp \vec{l}, \vec{B}$ ∧ $\vec{l} \perp \vec{B}$




Sl. 2.

Provodnik se ~~kreće~~ dok ima komponente sile duž x ose (sl. 3)

kad imamo samo y komp. sile $\vec{F}_R = \vec{F}_{Ry}$ Tada se tijelo ~~zaustavlja~~. Tada je




Sl. 3.

$\sphericalangle(\vec{F}_g, \vec{F}_R) = \alpha$

$\vec{F}_R = \vec{F}_g + \vec{F}_A$ ; $F_A = IlB$ ; $F_g = mg$

~~sin α = ...~~ $\quad tg\,\alpha = \dfrac{F_A}{F_g}$

$$tg\,\alpha = \frac{IlB}{mg} \Rightarrow \boxed{\alpha = \text{arc}\,tg\,\frac{IlB}{mg}}$$

$$\boxed{\alpha = \text{arc}\,tg\,\frac{1}{2}}$$