1 We look at two ways to solve this problem,

Due to the superposition principle we can view the charge in two parts, infinite plane with charge density $+\sigma$, and a disk with charge $-\sigma$. Together they give us the desired charge distribution. For the infinite plane we get according to section II-6.3 in the book

$$\bar{E} = \frac{\sigma}{2\epsilon_0}\hat{k} \qquad \text{above the plane}$$

and over the center of the disk we have, according to Ex. 5.8

$$\bar{E} = -\frac{\sigma}{2\epsilon_0}\left\{1 - \frac{h}{\sqrt{a^2+h^2}}\right\}\hat{k}$$

$$\to \bar{E} = \frac{\sigma}{2\epsilon_0}\left\{1 - 1 + \frac{h}{\sqrt{a^2+h^2}}\right\}\hat{k} = \boxed{\frac{\sigma}{2\epsilon_0}\frac{h}{\sqrt{a^2+h^2}}\hat{k}}$$

we can also use direct integration (compare to Ex. 5.8 again)

$$\bar{E} = \frac{\sigma}{4\pi\epsilon_0}\int_a^\infty r\,dr \int_0^{2\pi} d\theta\, \frac{h}{(r^2+h^2)^{3/2}}\hat{k}$$

$$= \frac{\sigma h}{2\epsilon_0}\int_a^\infty \frac{r\,dr}{(r^2+h^2)^{3/2}}\hat{k} = \frac{\sigma h}{2\epsilon_0}\left\{-\frac{1}{\sqrt{r^2+h^2}}\Big|_a^\infty\right\}\hat{k}$$

$$= 0 + \frac{\sigma h}{2\epsilon_0}\frac{1}{\sqrt{a^2+h^2}}\hat{k}$$

b) $h = 0 \to \underline{\bar{E} = 0}$ due to the symmetric cancellations of all contribution to the field in the center of the hole. The z-component is 0 as all contributions to the field are in the plane of the charge

c) $h >> a$

$$\bar{E} = \frac{\sigma}{2\epsilon_0}\frac{h\hat{k}}{\sqrt{a^2+h^2}} = \frac{\sigma}{2\epsilon_0}\left\{\frac{h}{h}\frac{1}{\sqrt{1+(\frac{a}{h})^2}}\right\}\hat{k}$$

$$= \frac{\sigma}{2\epsilon_0}\frac{\hat{k}}{\sqrt{1+(\frac{a}{h})^2}} \xrightarrow{h>>a} \boxed{\frac{\sigma\hat{k}}{2\epsilon_0}}$$

as far enough away no hole is seen anymore

2 Poiseuille's law

$$Q = \frac{(P_2-P_1)\pi r^4}{8\eta l}$$

$$\to \Delta Q = \frac{(P_2-P_1)\pi}{8\eta l}(r+\Delta r)^4 = \frac{(P_2-P_1)\pi}{8\eta l}r^4\left(1+\frac{\Delta r}{r}\right)^4$$

$$= Q\left(1+\frac{\Delta r}{r}\right)^4$$

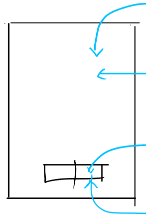
$$\to \frac{\Delta Q}{Q} = \left(1+\frac{\Delta r}{r}\right)^4$$

we want to find $\frac{\Delta r}{r}$ when $\frac{\Delta Q}{Q} = 10$

$$\to \left(1+\frac{\Delta r}{r}\right)^4 = 10 \quad \to \quad \frac{\Delta r}{r} = 10^{1/4} - 1 = 0,778$$

→ in order to increase the flow 10-fold, we need apptoximately 78% increase of the radius of the artery

3



$n = 0,630$ mol air

$T_i = 25$ °C

50 g iron

$E_{kin} = 60$ J

$R = 8,31 \frac{J}{mol}$ °C

$c = 452$ J/kg °C

$C_v = 2.50\,R$ (II-Tab. 2.3) N_2

$$E_{kin} = nC_v\Delta T + mc\Delta T = \{nC_v + mc\}\Delta T$$

$$\to \Delta T = \frac{E_{kin}}{\{nC_v + mc\}} = \frac{60\,J}{\{0,630 \cdot 2.50 \cdot 8,31 + 0,050 \cdot 452\}\,J/K}$$

$$\to \underline{\Delta T = 1,68\ °C} \quad \to \quad T_f = T_i + \Delta T = 25,0 + 1,68\ °C$$

b) The temperature changes

$$\Delta S = \int_A^B \frac{dQ}{T} = \int_{T_i}^{T_f}\left[\frac{nC_v\,dT}{T} + \frac{mc\,dT}{T}\right]$$

(5)

$$\Delta S = \left[nC_v + mc\right] \ln T \Big|_{T_i}^{T_f} = \left[nC_v + mc\right] \ln\left(\frac{T_f}{T_i}\right)$$

$$= \left[0{,}630 \cdot 2{,}5 \cdot 8{,}31 + 0{,}050 \cdot 452\right] \ln\left(1 + \frac{\Delta T}{T_i}\right)$$

$$= \underline{0{,}20 \ \frac{J}{K}}$$

(4) $E = 9{,}00$ kJ needed

a) Find C at $V = 12.0$ V

$$U_C = \frac{1}{2}V^2 C \longrightarrow C = \frac{2U_C}{V^2} = \frac{2E}{V^2} = \frac{2 \cdot 9 \cdot 10^3}{12^2} \frac{J}{V^2}$$
$$= \underline{125 \ F}$$

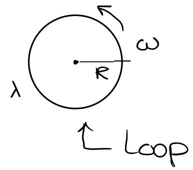
b) Very Large C! Compare to Ex. 8.2

Batteries are sold with Ahr rating

1 Ahr $= 1 \cdot 3600 \cdot 12 = 43{,}2$ kJ, common size 60 Ahr

(6)

(5)



$$\vec{B} = \frac{\mu_0}{4\pi} \oint \frac{I \, d\vec{l} \times \hat{r}}{r^2}$$

$$\longrightarrow B = \frac{\mu_0 I \, 2\pi}{4\pi R} = \frac{\mu_0 I}{2R}$$

$$\lambda = \frac{Q}{2\pi R}, \quad I = \frac{Q}{T} = Qf = \frac{Q\omega}{2\pi} = \frac{2\pi \lambda R \omega}{2\pi}$$

$$\longrightarrow B = \frac{\mu_0 \lambda \omega}{2}$$

and compared to the indicated direction of rotation the direction of B, the vector, is out of the page, perpendicular to it, as can be seen be the right hand rule