Chapter **23** (Benson)

E02 (**a**) $F = eE = 1.92{\times}10^{-17}$ N; (**b**) $a = F/m = 1.15{\times}10^{10}$ m/s^2 .

E05 (**a**) $E_y = -12kQ/\sqrt{2}L^2$, $E_x = 0$; (**b**) $E_x = -8kQ/5\sqrt{5}L^2$, $E_y = -12kQ[1 + 1/5\sqrt{5}]/L^2$.

E13 $\vec{E} = kQ\,\hat{r}/r^2$, $E_x = \vec{E}\cdot\hat{i} = kQx/r^3$, etc. .

E14 $E = kQ/r^2$: (**a**) $2.25{\times}10^{21}$ N/C; (**b**) $5.13{\times}10^{11}$ N/C .

E19 (**a**) $E_y = 0$, $E_x = 2kq[1/x^2 - x/(x^2 + a^2)^{3/2}] = (2kq/x^2)[1 - 1/(1 + a^2/x^2)^{3/2}]$; (**b**) $E_x = 0$, $E_y = 2kq/y^2 - kq/(y - a)^2 - kq/(y + a)^2 = 2kq[1/y^2 - (y^2 + a^2)/(y^2 - a^2)^2] = 2kqa^2(a^2 - 3y^2)/y^2(y^2 - a^2)^2$; (**c**) For $x \gg a$, $E_x \approx 3kqa^2/x^4$; for $y \gg a$, $E_y \approx -6kqa^2/y^4$.

E28 $v = 5{\times}10^6$ m/s & $\Delta x = 1.6$ cm. $\Delta K = (eE)\Delta x$, so $E = \Delta K/(e\Delta x) = mv^2/(2e\Delta x) = 4450$ N/C .

E30 $t{=}L/v{=}\ 2{\times}10^{-8}$ s, $\Delta y{=}at^2/2{=}\ 8{\times}10^{-3}$, From $a{=}eE/m$, find $E = 228$ N/C .

E33 $d = 2$ cm, $E = 10^3$ N/c & $\theta_0 = 45^0$. $(v_0 \sin\theta_0)^2 - 2(eE/m)d \le 0$, leads to $v_0 \le (2eEd/m)^{1/2}/\sin\theta_0 = 3.75{\times}10^6$ m/s .

E35 $E_{+2} = \sigma/\epsilon_0$, $E_{-2} = \sigma/\epsilon_0$, $E_{-1} = \sigma/2\epsilon_0$. For region I, $E = -E_{+2}+E_{-2}+E_{-1} = \sigma/2\epsilon_0$; For region II, $E = E_{+2}+E_{-2}+E_{-1} = 5\sigma/2\epsilon_0$; For region III, $E = E_{+2}-E_{-2}+E_{-1} = \sigma/2\epsilon_0$; For region IV, $E = E_{+2} - E_{-2} - E_{-1} = -\sigma/2\epsilon_0$.

E40 (**a**) For an infinite line of charges, the electric field is $E = 2k\lambda/r$, directed perpendicularly to the line. (**b**) By superposition, find $\vec{E} = 2k\lambda\,(\hat{i}/x + \hat{j}/y)$.

E49 Form vertex to center $d{=}L/\sqrt{3}$. By symmetry, $E_x{=}0$, $E_y = 2kQ\sin 30^0/d^2 + kQ/d^2 = 6kQ/L^2$.

P02 (**a**) $E = 2\pi k\lambda Rx/(x^2 + R^2)^{3/2}$; (**b**) Set $dE/dx = 0$ to find $x = \pm R/\sqrt{2}$; (**c**) $2\pi k\lambda R/x^2$.

P07 $E_x = 0$, $dE_y = k\lambda dx\cos\theta/r^2$, where $\cos\theta = y/r$ & $r^2 = y^2 + x^2$. $E_y = k\lambda y\int dx/(x^2 + y^2)^{3/2} = k\lambda xy/[y^2(x^2+y^2)^{1/2}]|_{-L/2}^{L/2} = 2kQ/[y(L^2+4y^2)^{1/2}]$. (**a**) As $y \gg L$, $E_y = kQ/y^2$; (**b**) $E_y = 2kQ/yL$ as $y \ll L$.

P12 (**a**) $E_y = 0$, $dE_x = k\lambda dx/x^2$, $E_x = k\lambda/R$; (**b**) $dE_x = dE\sin\theta = k\lambda xdx/(x^2 + R^2)^{3/2}$, $E_x = k\lambda[-1/(x^2 + R^2)^{1/2}]|_0^\infty = k\lambda/R$, $dE_y = dE\cos\theta = k\lambda Rdx/(x^2 + R^2)^{3/2}$, $E_y = k\lambda Rx/[R^2(x^2 + R^2)^{1/2}]|_0^\infty = k\lambda/R$. (Teacher: Jyh-Shinn Yang, 90.04.06)

P13 (**a**) $E_y = 0$, $E_x = (2kQ/r)(x/r) = 2kQx/(x^2 + a^2)^{3/2}$; (**b**) $E_x = 2kQ/x^2$ for $x \gg a$; (**c**) Set $dE_x = /dx = 0$ to find $x = \pm a/\sqrt{2}$.

P14 (**a**) $E(x) = kQx/(x^2 + R^2)^{3/2} \approx kQx/R^3$, as $x \ll R$; (**b**) $F = -qE = -(kqQ/R^3)x$. Since $F = -Cx$, motion is SHM; (**b**) $d^2x/dt^2 + (kqQ/mR^3)x = 0$, thus $\omega^2 = kqQ/mR^3$.

P16 $y = \tan\theta_0\,x - ax^2/(2v_0^2\cos^2\theta)$, with $a = eE/m_e$. As $x = v_0^2\tan\theta_0\cos^2\theta_0/g$, y is maximum. Set $y = d/2$ to obtain $v_0 = \sqrt{ad}/\sin\theta_0 \equiv v_0^{max}$. For e not to touch the bottom plate,

$y \geq -d/2$ as $x = L$. Thus $v_0^{min} = aL/[2\cos^2\theta_0(\tan\theta_0 + d/2L)$ Using d=1 cm, L=4 cm & E=10^3 N/C, we have $v_0^{max} = 2.65{\times}10^6$ m/s & $v_0^{min} = 2.58{\times}10^6$ m/s .