1. (i) B

   (ii) B

   (iii) D

   (iv) either C or D due to typeset error

   (v) B

   (vi) D

2. Part (a): (i) Approach 1:

$$\begin{aligned}\oint \mathbf{E}\cdot d\mathbf{l} &= \int_{-1}^{1} 2du + \int_{-1}^{1} -3dy + \int_{1}^{-1} 2du + \int_{1}^{-1} -3dy \\ &= 4 - 6 - 4 + 6 \\ &= 0.\end{aligned}$$

   Approach 2: $\nabla \times \mathbf{E} = 0$ so $\oint \mathbf{E}\cdot d\mathbf{l} = 0$.

   (ii)

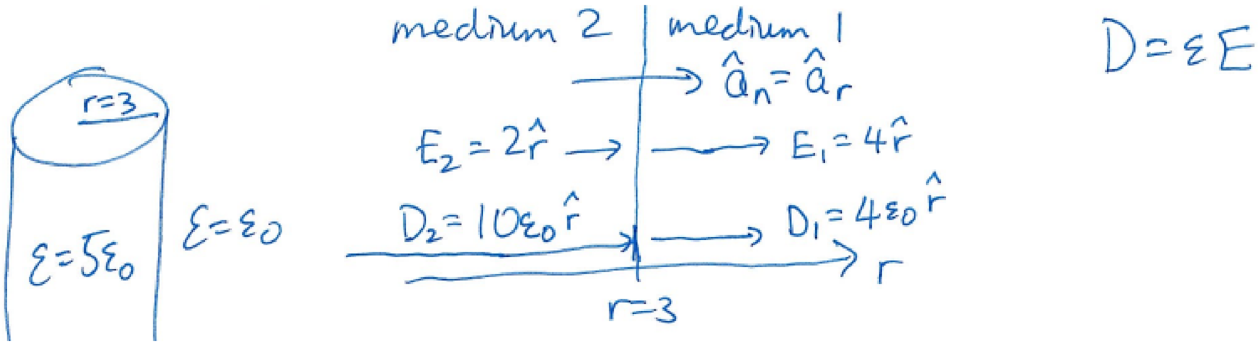
$$\begin{aligned}V(a) - V(b) &= -\int_{b}^{a} \mathbf{E}\cdot d\mathbf{l} \\ &= -\int_{-1}^{1} 2du - \int_{-1}^{1} -3dy \\ &= -4 + 6 \\ &= 2V\end{aligned}$$

   Part (b): (i) By Stoke's theorem,

$$\begin{aligned}\oint \mathbf{E}\cdot d\mathbf{l} &= \iint_S (\nabla \times \mathbf{E})\cdot d\mathbf{S} \\ &= \iint_S (2\hat{x} - 3\hat{y} + 5\hat{z})\cdot(dxdy\hat{z}) \\ &= \int_{-1}^{1}\int_{-1}^{1} 5dxdy \\ &= 5 \times 4 \\ &= 20V\end{aligned}$$

   (ii) E since we have a nonconservative field

3. (a)



We have $D_{1n} - D_{2n} = \rho_s$ so $\rho_s = 4\epsilon_0 - 10\epsilon_0 = -6\epsilon_0 [C/m^2]$

(b) Use Gauss's law with cylinder of radius 3 and length L.

$$\iint_S \mathbf{D} \cdot d\mathbf{S} = Q_{enc}$$
$$D_{2n} 2\pi r L = Q_{enc}$$
$$Q_{enc}/L = D_{2n} 2\pi r = 60\pi\epsilon_o [C/m]$$

4. (a) False

(b) False

(c) $\frac{-Q}{4\pi\epsilon r^2}\hat{r}[V/m]$

(d) Note flow is inward and constant on a sphere of radius r_o and $d\mathbf{S}$ points outwards by the following:

$$\mathbf{J} = \frac{-\sigma Q}{4\pi\epsilon r^2}\hat{r}$$

We have

$$\begin{aligned} I &= \iint \mathbf{J} \cdot d\mathbf{S} \\ &= \iint |J||dS|(-1) \\ &= -|J|(area\ of\ sphere) \\ &= -|\frac{-\sigma Q}{4\pi\epsilon r^2}|4\pi r^2 \\ &= -\frac{\sigma Q}{\epsilon}[A] \end{aligned}$$

(e) Note $d\mathbf{l} = dr\hat{r}$ below

$$\begin{aligned}
V(b) - V(a) &= -\int_a^b \mathbf{E}\cdot d\mathbf{l} \\
&= -\int_a^b \frac{-Q}{4\pi\epsilon r^2} dr\hat{r} \\
&= \int_a^b \frac{Q}{4\pi\epsilon r^2} dr\hat{r} \\
&= \frac{-Q}{4\pi\epsilon r}\Big|_a^b \\
&= \frac{Q}{4\pi\epsilon}(\frac{1}{a} - \frac{1}{b})
\end{aligned}$$

Hence

$$V_o = \frac{Q}{4\pi\epsilon}(\frac{b-a}{ab})[V]$$

$$Q = 4\pi\epsilon V_o(\frac{ab}{b-a})[C]$$

(f)

$$\begin{aligned}
G &= \frac{|I|}{V_o} \\
&= \frac{\sigma Q}{\epsilon V_o} \\
&= \frac{\sigma}{\epsilon} 4\pi\epsilon(\frac{ab}{b-a}) \\
&= \sigma 4\pi(\frac{ab}{b-a})[Siemens]
\end{aligned}$$