The figure here shows four closed surfaces with flat top and bottom faces and curved sides. The table gives the areas $A$ of the faces and the magnitudes $B$ of the uniform and perpendicular magnetic fields through those faces; the units of $A$ and $B$ are arbitrary but consistent. Rank the surfaces according to the magnitudes of the magnetic flux through their curved sides, greatest first.

<table>
<thead>
<tr>
<th>Surface</th>
<th>$A_{\text{top}}$</th>
<th>$B_{\text{top}}$</th>
<th>$A_{\text{bop}}$</th>
<th>$B_{\text{bop}}$</th>
<th>Magnetic Flux through Curved Sides</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a$</td>
<td>2</td>
<td>6, outward</td>
<td>4</td>
<td>3, inward</td>
<td>$\Phi_{\text{top}} = 12, \Phi_{\text{bot}} = -12 \Rightarrow \Phi_{\text{side}} = 0$</td>
</tr>
<tr>
<td>$b$</td>
<td>2</td>
<td>1, inward</td>
<td>4</td>
<td>2, inward</td>
<td>$\Phi_{\text{top}} = -2, \Phi_{\text{bot}} = -8 \Rightarrow \Phi_{\text{side}} = 10$</td>
</tr>
<tr>
<td>$c$</td>
<td>2</td>
<td>6, inward</td>
<td>2</td>
<td>8, outward</td>
<td>$\Phi_{\text{top}} = -12, \Phi_{\text{bot}} = 16 \Rightarrow \Phi_{\text{side}} = -4$</td>
</tr>
<tr>
<td>$d$</td>
<td>2</td>
<td>3, outward</td>
<td>3</td>
<td>2, outward</td>
<td>$\Phi_{\text{top}} = 6, \Phi_{\text{bot}} = 6 \Rightarrow \Phi_{\text{side}} = -12$</td>
</tr>
</tbody>
</table>
The figure shows graphs of the electric field magnitude $E$ versus time $t$ for four uniform electric fields, all contained within identical circular regions as in Fig. above. Rank the fields according to the magnitudes of the magnetic fields they induce at the edge of the region, greatest first.

\[ \Phi_E = \oint_B \mathbf{B} \cdot d\mathbf{s} = \mu_0 \varepsilon_0 \frac{d\Phi_E}{dt} \]

Flux of electric field through the surfaces bounded by that line
7. (18 points).
The figure shows a parallel plate capacitor with radius $R = 5 \text{ cm}$ and distance between the plates $d = 3 \text{ mm}$ being charged by a current of 2.5 A.

i) (4 points) Calculate the rate change of the magnitude of the electric field, $\frac{dE}{dt}$, in the capacitor.

\[
E = \frac{\frac{2.5}{\varepsilon_0 A}}{
\Rightarrow \frac{dE}{dt} = \frac{1}{\varepsilon_0 A} \cdot i
\]

\[
= \frac{2.5}{\varepsilon_0 \cdot \pi (0.05)^2} = 3.6 \times 10^{12} \left[ \frac{\text{V}}{\text{m} \cdot \text{s}} \right]
\]
7. (18 points).
The figure shows a parallel plate capacitor with radius $R = 5$ cm and distance between the plates $d = 3$ mm being charged by a current of 2.5 A.

i) (4 points) Calculate the rate change of the magnitude of the electric field, $\frac{dE}{dt}$, in the capacitor.

$$E = \frac{Q}{\varepsilon_0 A}$$

$$\Rightarrow \frac{dE}{dt} = \frac{1}{\varepsilon_0 A} \cdot i$$

ii) (7 points) Calculate the displacement current penetrating an imaginary circle of radius $r = 10$ cm centered at the axis of the current.

$$i_d = \varepsilon_0 \cdot \frac{d\Phi}{dt} = \varepsilon_0 \frac{dE}{dt} \cdot A$$

$$= \varepsilon_0 \frac{dE}{dt} \cdot \pi (0.05)^2 = 2.5 \text{ [A]}$$
7. (18 points).
The figure shows a parallel plate capacitor with radius $R = 5$ cm and distance between the plates $d = 3$ mm being charged by a current of 2.5 A.

i) (4 points) Calculate the rate change of the magnitude of the electric field, $\frac{dE}{dt}$, in the capacitor.

$$ E = \frac{\rho}{\varepsilon_0 A} $$

$$ \Rightarrow \frac{dE}{dt} = \frac{1}{\varepsilon_0 A} \cdot i $$

iii) (3 points) What is the direction of the displacement current found in (iii)?

- Rightward
- Leftward
- Zero
7. (18 points).
The figure shows a parallel plate capacitor with radius \( R = 5 \) cm and distance between the plates \( d = 3 \) mm being charged by a current of 2.5 A.

i) (4 points) Calculate the rate change of the magnitude of the electric field, \( \frac{dE}{dt} \), in the capacitor.

\[
E = \frac{2i}{\varepsilon_0 A}
\]

\[
\Rightarrow \frac{dE}{dt} = \frac{1}{\varepsilon_0 A} \cdot i
\]

iv) (4 points) The displacement current penetrating an imaginary circle of radius \( r = 2.5 \) cm centered at the axis of the current is \______\: (Choose one correct answer).

(a) Larger than the one found in (iii)
(b) Smaller than the one found in (iii)
(c) Same as the one found in (iii)
(d) Not be determined with given information
7. (18 points).
The figure shows a parallel plate capacitor with radius $R = 5$ cm and distance between the plates $d = 3$ mm being charged by a current of 2.5 A.

i) (4 points) Calculate the rate change of the magnitude of the electric field, $\frac{dE}{dt}$, in the capacitor.

$$ E = \frac{\varepsilon_0 i}{A} $$

$$ \Rightarrow \frac{dE}{dt} = \frac{1}{\varepsilon_0 A} \cdot i $$

$$ = \frac{2.5}{\varepsilon_0 \cdot \pi (0.05)^2} = 3.6 \times 10^{12} \text{ [V/m.s]} $$
6. (8 points).
A closed surface is shown in the figure. Through the top surface, there is a magnetic flux of +6 mWb, where the flux directed outwards is taken positive. No magnetic flux penetrates the four side faces.

i) (4 points) Through the bottom face, the magnetic flux is: (choose one correct answer)

(a) Positive 
(b) Negative 
(c) Zero 
(d) Not enough information 

ii) (4 points) Along the bottom face, the direction of the magnetic field is: (choose one correct answer)

(a) The same as the direction of the magnetic field along the top face 
(b) Opposite to the direction of the magnetic field along the top face 
(c) Zero, regardless the direction of the magnetic field along the top face 
(d) Not enough information