



# IEST5004

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HYfa `H\fYY`##`&\$&\$

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7 ci fgY`Cj Yfj ]Yk

GHJZZ`7cbHJW`8YHU]`g

7cbj Ybcfg

B Ua Y	9a U]	5j U]UV]]m	@cWU]cb	D\cbY
HYa U`A ]`ghY]b	hYa U"a ]`ghY]b4 i bgk "YXi "Ui	6mUddc]bha Ybh Xi f]b[ `Wcbgi `hU]cb \ci fg fK YXbYgXUmž%% U"a "!"%&"d"a "L	A cfj Yb`6fck b ' * ( `fcb`cb]bY j ]U`HYUa g`Xi Y hc `X]ghUbW `YUfb]b[ `cf 7cj ]XŁ	

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GWXcc``cZ<i a Ub]hYg`UbX`@Ub[ i U[ Yg

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CdYb]b[ `<ci fg.`A cbXUm!`:`f]XUmž`- Ua `!`) da

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9a U]: [\U`4 i bgk "YXi "Ui](#)

7ci fgY'8YHJ]`g

7fYX]hDc]bhtg`\*`

Gi a a UfmicZ\hY'7ci fgY

H\Y'cV'YW]j Y'cZ\hY'9bj ]fcb a YbH U`A UbU[ Ya Ybh]bHfYbg\]d` ]g`hc`dfcj ]XY'mci`k ]h`h`Y'cddcfh b]hmhc`k cf\_ k ]h`Yi dYf]YbW\X'Ybj ]fcb a YbH U`dfUW]h]cbYfg`]b`U`dfcZ'gg]cbU`gYH]b[ "Mci`k ]`i`gY`h`Y`\_bck`YX[ Y [ U]bYX`]b`dfYj ]ci`g`A`9A`'Wci`fgYgZ`UbX`hc`Udd`m]h`hc`dfc`Y`W`h`U`g`\_`g`h`fci`[`\`ci`h`h`Y`]b`H`f`b`g`\]d`"8YHJ]g`cZ\hY`H`U`g`\_`g`k`]"`V`Y`U`ff`U`b[`Y`X`]b`W`cb`gi`h`U`h]cb`k`]h`h`h`Y`W`ci`fgY`W`c`f`X]b`U`h`c`f`c`f`a`i`h`i`U`m`U[`f`Y`Y`X`i`d`c`b`U`W`U`X`Y`a`]W`g`h`U`Z`g`i`d`Y`f`]g`c`f`U`b`X`m`ci`f`c`b`!`g`]H`Y`g`i`d`Y`f`]g`c`f`U`b`U`d`d`f`c`j`Y`X`g`h`U`Z`a`Y`a`V`Y`f`k`]h`h`]b`d`f`j`U`H`Y`c`f`d`i`V`]W`g`Y`W`c`f`]b`g`h`i`h`c`b`c`f`c`f[`U`b]g`U`h]cb`E`"D`f`c`f`hc`d`U`W`Y`a`Y`b`h`g`]b`c`f[`U`b]g`U`h]cb`g`Z`h`Y`W`ci`fgY`W`c`f`X]b`U`h`c`f`k`]"`k`cf`\_`k`]h`m`ci`U`b`X`h`h`Y`U[`Y`b`W`Y`g`hc`Y`b`gi`f`Y`m`ci`U`f`Y`Z`"m`d`f`Y`d`U`f`Y`X`U`b`X`h`h`U`h`h`Y`d`f`c`Y`W`h]g`U`d`d`f`c`d`f]U`H`Y`"

7ci fgY'@YUfb]b[ `Ci hWca Yg

- %`Gh`XY`b`h`g`"Y`U`f`b`"ck`hc`XY`j`Y`cd`U`d`f`c`Z`'gg]cbU`#`Y`g`Y`U`f`W`X`d`f`c`Y`W`h`h`f`ci`[`\`"U]g`c`b`k`]h`U`d`U`f`h`b`Y`f`c`f[`U`b]g`U`h]cb`
- &"`Gh`XY`b`h`g`'a`i`gh`XY`j`Y`cd`d`f`c`Y`W`h`U]a`g`U`b`X`g`W`c`d`Y`
- '`"K`]h`h`h`Y`d`U`f`h`b`Y`f`c`f[`U`b]g`U`h]cb`z`gh`XY`b`h`g`'a`i`gh`XY`j`Y`cd`U`b`X`U`d`d`m`U`d`d`f`c`d`f]U`H`Y`'a`Y`h`c`X`c`c`[`]Y`g`hc`U`X`X`f`Y`g`g`h`h`Y`U]a`g`c`Z`h`Y`c`f[`U`b]g`U`h]cb`U`b`X`h`h`Y`g`h`XY`b`h`d`f`c`Y`W`h`
- (`"Gh`XY`b`h`g`"Y`U`f`b`hc`W`c`b`X`i`W`h`]h`f`U`h`f`Y`f`Y`j`Y`k`g`]b`hc`U`X`X`f`Y`g`g`g`d`Y`W`Z]W`f`Y`g`Y`Y`U`f`W`X`hc`d]W`g`"
- )`"Gh`XY`b`h`g`U`b`U`mg`Y`Z`f`Y`d`c`f`h`U`b`X`]b`H`Y`d`f`Y`h`Z]b`X]b[`g`
- \*`"Gh`XY`b`h`g`"Y`U`f`b`hc`XY`]j`Y`f`W`c`b`W`i`g]c`b`g`U`b`X`f`Y`W`c`a`a`Y`b`X`U`h]c`b`g`h`h`f`ci`[`\`f`Y`d`c`f`h]b[`U`b`X`c`f`U`"XY`]j`Y`f`m`"

HYUWX]b[ `GhfUHY[ ]Yg`

HYUWX]b[ `ghfUHY[ ]Yg`]b`W`i`XY`W`c`b`gi`h`U`h]cb`U`b`X`g`i`d`Y`f`]g]c`b`a`Y`Y`h]b[`g`k`]h`m`ci`f`W`ci`fgY`W`c`f`X]b`U`h`c`f`c`f`a`i`h`i`U`m`U[`f`Y`Y`X`i`d`c`b`U`W`U`X`Y`a`]W`g`h`U`Z`g`i`d`Y`f`]g`c`f`Z`U`U`b`X`g]c`b`k`c`f\_]b[ `f`Y`U`h]c`b`g`\]d`k`]h`m`ci`f`c`g`h`c`f[`U`b]g`U`h]cb`z`U`b`X`f`Y`d`c`f`h]b[ `j`]U`h`h`Y`W`ci`fgY`U`g`g`Y`g`g`a`Y`b`h`g`"

## 5ggYgga Ybh

H\Y`Zcfa Uħ`Yb[ ĤžUbX`gWcY`cZU`Ugg][ ba Ybhg`]g`Zc`bY[ cĤUĤcb`VYĤ`YYb`mci žmci f`U[ fYYX!i dcb ]bhYfbg\]d`gi dYfj`]gcf`UbX`mci f`cgĤcf[ Ub]gUĤcb" `A cFY`[ i ]XUbW`k ]`VY`[ ]j Yb`]b`Wcbgi`ĤUĤcb`a`YYĤb[ g YUfm]b`ĤY`HYfa`k ]Ĥ`mci f`gi dYfj`]gcf`UbX`cgĤcf[ Ub]nUĤcb"

## 5ggYgga YbhHUg\_g`

5ggYgga YbhHUg_	K Y][ \h	8i Y`8UH`	GĤi XYbh@YUfb]b[ C i ĤWc a Yg`5ggYggYX
: ]bU`F Ydcfh	* \$i	Bch5dd`]WUV`Y	' ž( ž) ž*
C fU`dfYgYbhUĤcb`cZfYgi`Ĥg UbX`Z]bX]b[ g`cZ]bhYfbg\]d dfc`YWĤ	&\$i	Bch5dd`]WUV`Y	) ž*
ĤbhYfbg\]d`fYgYUfW`Vf]YZ	%)\$i	Bch5dd`]WUV`Y	%)ž&
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## 5ggYgga Ybh8YĤU]`g

5ggYgga Ybh% : ]bU`F Ydcfh

GĤUfhXUH`. Bch5dd`]WUV`Y

8YĤU]`g.: ]bU`fYdcfhXYĤU]`]b[ `U]a gžgWcYž`a`YĤcXgž`UWĤ] ]ĤYg`Wc`bXi`WĤXž`fYgi`Ĥg#Z]bX]b[ gž`fY`Y] Ubh ]ĤYUĤi`fYž`UbX`fYWc`a`a`YbXUĤcbg`Zc`f`ĤY`c`f[ Ub]nUĤcb"

F Yj ]Yk`VmWc`i`fgY`Wc`bj`Ybcf`UbX`Wc`a`a`Ybhg`Zc`a`c`f[ Ub]gUĤcb`gi`dYfj`]gcf"

5XX]ĤcbU`XYĤU]`g.

D`YUgY`Wc`bĤUWĤU`[ ccX!Z]h9bj`]fcba`YbhUbX`GcWYĤmUWUXYa`]WghUZZa`Ya`VYf`Ĥc`f`Yei`YghĤĤYmWc`!gi`dYfj`]gY`mci`f`k`c`f`\_`k`]Ĥ`mci`f`cgĤcf[ Ub]gUĤcb"

Gi Va ]gg]cb`bchYg.: i`XYĤU]`g`Ĥc`VY`bY[ cĤUĤX`k`]Ĥ`cgĤcf[ Ub]gUĤcb`UbX`]bhYfbg\]d`gi`dYfj`]gcf

Hi fb]Ĥb`gYĤĤb[ . H\]g`Ugg][ ba Ybh]g`gi`Va ]ĤYX`Ĥfci [ \`Hi`fb]Ĥb`UbX`gh`XYbhg`Xc`bchgYY`Hi`fb]Ĥb`g]a`]Uf]m`fYdcfhg"

5ggYgga Ybh&. C fU`dfYgYbhUĤcb`cZfYgi`Ĥg`UbX`Z]bX]b[ g`cZ]bhYfbg\]d`dfc`YWĤ

GĤUfhXUH`. Bch5dd`]WUV`Y

@Yb[ Ĥ. : i`XYĤU]`g`Ĥc`VY`bY[ cĤUĤX`k`]Ĥ`cgĤcf[ Ub]gUĤcb`UbX`]bhYfbg\]d`gi`dYfj`]gcf

8YĤU]`g.C fU`dfYgYbhUĤcb`cZ]bX]b[ g`Ĥc`k`UfXg`YbX`cZ]bhYfbg\]d`DUfĤbYf`UbX`Wc`bj`Ybcf`Wc`a`a`YbhUbX`Ĥ]g`dfcj`]XYg`Ugg]gĤUbW`k`]Ĥ`Z]bU`fYdcfhWc`a`d`YĤcb

5XX]ĤcbU`XYĤU]`g.

H\Y`Zcfa UhUbX`WcbHYbhk ]`VY`XYHYfa ]bYX`VmiHY` ]bHYfbg\]d`gi dYfj ]gcf`UbX`hY`cgchcf[ Ub]gUhc]b"

Gi Va ]gg]cb`bchYg.: i ``XYHU]g`tc`VY`bY[ ch]UHXY`k ]h\`cgchcf[ Ub]gUhc]b`UbX` ]bHYfbg\]d`gi dYfj ]gcf

Hi fb]h]b`gYH]b[ . H\]g ]g`bchU`Hi fb]h]b`Ugg][ ba Ybh

5ggYgga Ybh' . `bHYfbg\]d`fYgYUfVX`Vf]YZ

GHUfhXUH` . Bch5dd`]WV`Y

8YHU]`g.G\cfhVf]YZk ]h`dfc`YWHU]a gZgWcdY`UbX`YHYf`cZU[ fYYa Ybhk ]h`cf[ Ub]gUhc]b`]bWi`XYX"  
F Yj ]Yk`VmWci`fgY`Wcbj`Ybcf

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H\Y`Vf]YZZcf`hY` bHYfbg\]d`]g`YgHU]`g\YX` ]b`Wcbgi` ]h]cb`VYtk`YYb`hY` ]bHYfbg\]d`gi dYfj ]gcf`UbX`hY`  
\cgchcf[ Ub]gUhc]b" Bcfa U`miHY`Vf]YZk ]`VY`XYHYfa ]bYX`UbX`k`f]HYb`k ]h]b`hY`Z]fghk`c`k`YY`g`cZHY`  
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GHUfhXUH` . Bch5dd`]WV`Y

8YHU]`g. b`cfXYf`tc`Ugg]ghk ]h`gfi`XYbhdfc`YWHa`UbU[ Ya`Ybhig\_]`gZgfi`XYbfg`a`i`gh`YYd`UbX`gi`Va`]hU`X]Ufm  
fYdcfh]bX]WU]h]b[ `UW]j ]h]YgZ`dfc`YWHd`Ubb]b[ `UbX`h]a`Y` ]bYg"  
5ggYggYX`VmiHY`Wcbj`Ybcf

Gi Va ]gg]cb`bchYg.: i ``XYHU]g`tc`VY`bY[ ch]UHXY`k ]h\`cgchcf[ Ub]gUhc]b`UbX` ]bHYfbg\]d`gi dYfj ]gcf

Hi fb]h]b`gYH]b[ . H\]g ]g`bchU`Hi fb]h]b`Ugg][ ba Ybh

5 hYbXUbW F Yei ]fYa Ybhg

Gh XYbhg UfY ghfcb[ mYbWci fU[ YX'hc UhhYbX'U''WUggYg UbX'fYj ]Yk ''YWh fY'fYWcfX]b[ g"

7 ci fgY GWXYXi `Y

[J \]Yk WUgg'ha YhUVY](#)

H]a YhUV`Y`

8 UhY	HmdY	7 cbhYbh
K YY_%`%( 'GYdhYa VYf! % 'GYdhYa VYf	Dfc YWh	5`k YY_mgWXYXi `Y`]g`bchdfcj ]XYX`YfY""8i f]b[ `cf VYzcfY`hY`Z]fghk YY_cZHYfa ž`hY`gWcdY`cZhY ]bhYfbg\]d`bYYXg`hc`VY`XYhYfa ]bYX`]b`bY[ ch]U]cbg VYhk YYb`cgchcf[ Ub]gU]cbž`mci ž`UbX`mci fU[ fYXX! i`dcb`UWXYa ]WghUZZ]bhYfbg\]d`gi`dYfj ]gcf""5`c`hYf gWXYXi `]b[ `UbX`fYei ]fYa Ybhg`Zck`Zca`h`]g`YUfm YghUV`]g`a`YbhcZ`hY`]bhYfbg\]d`"

## F Ygci fWg

### DfYgWf]VYX`F Ygci fWg`

H\Y`fYgci fWg`bYYXYX`Zcf`mci f`bhfYfbg\`d`k`j`VY`XYH`fa`]bYX`VmiH`Y`gWd`dY`UbX`]bhYbhcZ`H`Y`dfc`YWZ`UbX`  
VmiH`Y`fYeI`]fYa`YbHg`cZ`mci f`cghcf[`Ub]gU]cb`UbX`mci f`U[`fYX`!i`dcb`UWUXYa`]WghUZZ`]bhYfbg\`d`  
gi`dYfj`]gcfZ`fY`UH`X`hc`mci f`hd]W

### F YWca a YbXYX`F Ygci fWg

Mci`UfY`YI`dYW`X`hc`YI`YfW]gY`U`\][`\`XY[`fYY`cZ]b]hU]j`Y`]b`Z]bX]b[`mci f`]bhYfbg\`d`UbX`fYgYUfW`a`UH`f]U`g`  
fY`Yj`UbhZcf`mci f`dfc`YW

### 7 ci fgY`9j`U`i`Uh]cb`UbX`8Yj`Y`cda`Ybh

@]\_Y`U`A`9A`Wci`fgYgZ`H`Y`UddfcUW`hc`H`Y`bhfYfbg\`d`]g`XYj`Y`cdYX`cb`H`Y`VUg]g`h`Uh]bXYdYbXYbhUbX`  
Udd`]YX`YUfb]b[`]g`\][`\`mj`U`i`YX`Vmigh`XYbHgZ`VUgYX`cb`dUghYI`dYf]YbW`UbX`dfYj`]ci`g`ZYXVUW`"  
Gh`XYbHg`\Uj`Y`U`gc`YI`dfYggYX`g]fcb[`]bhYfYgh]b`H`Y`YI`H`fbU`  
Wca`a`i`b]m#`cj`Yfba`Ybh#B`;`C`#bXi`glfmYI`dYf]YbW`h`UhH`Y`bhfYfbg\`d`c`ZYfg"

Gi Va ]gg]cb 'cZ5ggYgga YbhiHUg\_g

Hi fb]h]b 'Gi Va ]gg]cb

Ẓmci 'YbWci bHYf'U'dfcV'Ya 'k \Yb'UHYa dh]b[ 'hc'gi Va ]hmc i f'Ugg][ ba YbhiH'fci [ \ 'Hi fb]h]bž'd'YUgY  
HY'Yd\cbY'9I HYfbU'Gi ddcfhcb'- ' , ) " ' ' %cf'Ya U] 'H'Ya 'cb'YI HYfbU'HY'ngi ddcfh4 i bgk "YXi "Ui "'Gi ddcfh  
\ci fg'UfY' , .\$\$Ua '—%\$. \$\$da 'cb'k YY\_XUmg'UbX'-. .\$\$Ua '—) . \$\$da 'cb'k YY\_YbXg'fI \*) 'XUmg'U'mYUfI" Ẓmci  
UfY'i bUV'Y'hc'gi Va ]hmc i f'Ugg][ ba YbhiXi Y'hc'U'Zi 'hk ]H'Hi fb]h]b'mci 'a UmiUdd'm'Zc'f'Ub'YI HYbg]cbž'Vi hmc i  
a i ghfYH]b'mci f'h]W'Yhbi a VYf'Z'ca '9I HYfbU'Gi ddcfhfU'cb[ 'k ]H'Ubmich'Yf'fY'Yj UbhXcW a Yb'gk'hc  
]bWi XY'Ug'Yj ]XYbW'hc'gi ddcfhmc i f'YI HYbg]cb'Udd'j]W]h]cb" Ẓmci 'Ya U] '9I HYfbU'Gi ddcfhmc i 'k ]`



5 WUXYa ]W< cbYgmiUbX`D`U[ ]Uf]ga

D`U[ ]Uf]ga `]g`i`g]b[ `h`Y`k`c`f`X`g`c`f`]X`Y`U`g`c`Z`c`h`Y`f`g`i`U`b`X`d`f`Y`g`Y`b`h]b[ `h`Y`a` `U`g`m`c`i`f`c`k`b`" `#`W`b`h`U`\_`Y`a`U`b`m`  
Z`c`f`a`g`Z`Z`c`a` `X`Y`]V`Y`f`U`h`Y` `W`X`Y`U`h]b[ `h`c` `U`W`W`Y`X`Y`b`h`U` `m`i`W`c`d`m]b[ `Z`c`a` `U`g`c`i`f`W`k`]h`c`i`h`U`W`b`c`k` `Y`X[ `Y`a` `Y`b`h`

- i bXYfgHUbX'mci f'f][ \hg'UbX'fYgdcbg]V] ]hYg'Ug'U'gh XYbhUhl BGK
- VY'Uk UfY'cZd'U[ ]Uf]ga ž'Wcdmf][ \hž' BGK 'Gh XYbh7cXY'cZ7cbXi WñUbX'5WwdfUV'Y'I gY'cZ  
I BGK '⇒H'F Ygci fW'g'Dc`]Wñ

## 5 WUXYa ]WbZcfa Uh]cb

: cfYggYbh]U`gh XYbh]bZcfa Uh]cb fY`Uh]b[ `tc.

- fYei Yghg`Zcf`YI H`bg]cb/
- `UhY`gi Va ]gg]cbg`[ i ]XY`]bYg/
- fYj ]Yk `cZa Uf\_g/
- I BGK `<YU`h`UbX`GUZYmidc`]WYg/
- YI Ua ]bUh]cb`dfcW`Xi fYg/
- gdYW]U`W`bg]XYfUh]cb`]b`hY`Yj YbhicZ]`bYgg`cf`a ]gUXj Ybh fY/
- gh XYbhYei ]m]UbX`X]gUV`]m/
- UbX`c`hYf`YggYbh]U`UWUXYa ]W]bZcfa Uh]cbz`gYY

[\ftdg.#k k k "Uftg"i bgk "YXi "Ui #W ffYbh\]gh XYbh\]UWUXYa \]W\]bZcfa Uh\]cb#dfch`W`g`\[ i \]XY`\]bYg#](#)

⇒ U[ Y`7 fYX]h

D\chc`Vm8Ub]Y`F cV]bgcb

7F ⇒ CG

7F ⇒ CG`Dfcj ]XYf`7cXY.`\$\$\$- ;

5W\_bck`YX[ Ya YbhicZ7ci bhfm

K Y`UW\_bck`YX[ Y`hY`6YXY[ U`dYcd`Y`k`c`UfY`hY`fUX]h]cbU`W`ghcX]Ubg`cZ`hY`UbXg`cb`k`\]W`I BGK  
? Ybg]b[ hcb`W]a di g`]g`cW]hYX"