



# IEST5004

9bj ]fcba YbH`A UbU[ Ya YbhF YgYUfWk `bHfbg\]d

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

GWXcc`cZ<i a Ub]hYg`UbX`@Ub[ i U[ Yg`##`I BGK ``5fmg`UbX`GcWU`GWYbWg

7 ci fgY`Cj Yfj ]Yk

GHJZZ`7cbHJW`8YHJ]`g

7cbj Ybcfg

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

GWXcc``7cbHJW`bZcfa Uh]cb

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

@cW]h]cb. `GWXcc``C Z]W]žA cfj Yb`6fck b`6i ]X]b[ ž@Yj Y``ž&),

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

D\cbY. `ž\*%&`-' , ) `%\*, %

: U! . `ž\*%&`-' , ) `; , +\$)

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`V`ci`fgYgZ`UbX`hc`Udd`m]h`hc`dfc`Y`W`h`U`g`\_`g`h`f`ci`[`\`ci`h`h`Y`]b`H`f`Y`b`g`\]d`"8YHJ]g`cZ\hY`H`U`g`\_`g`k`]"`V`Y`U`ff`U`b[`Y`X`]b`V`cb`gi`h`U`h`c`b`k`]h`h`h`Y`V`ci`fgY`V`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`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`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`c`b`E`"D`f`c`f`hc`d`U`W`Y`a`Y`b`h`g`]b`c`f`[`U`b`]g`U`h`c`b`g`Z`h`Y`V`ci`fgY`V`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

- %`G`h`X`Y`b`h`g`"Y`U`f`b`h`c`k`h`c`X`Y`j`Y`c`d`U`d`f`c`Z`'g`g`]c`b`U`#`Y`g`Y`U`f`W`X`d`f`c`Y`W`h`h`f`c`i`[`\`"U`]g`c`b`k`]h`h`U`d`U`f`h`b`Y`f`c`f`[`U`b`]g`U`h`c`b`
- &"`G`h`X`Y`b`h`g`a`i`g`h`X`Y`j`Y`c`d`d`f`c`Y`W`h`U`]a`g`U`b`X`g`V`c`d`Y`
- '`"K`]h`h`h`Y`d`U`f`h`b`Y`f`c`f`[`U`b`]g`U`h`c`b`Z`g`h`X`Y`b`h`g`a`i`g`h`X`Y`j`Y`c`d`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`h`c`U`X`X`f`Y`g`g`h`h`Y`U`]a`g`c`Z`h`Y`c`f`[`U`b`]g`U`h`c`b`U`b`X`h`h`Y`g`h`X`Y`b`h`d`f`c`Y`W`h`
- (`"G`h`X`Y`b`h`g`"Y`U`f`b`h`c`V`c`b`X`i`V`h`i`h`f`U`h`f`Y`f`Y`j`Y`k`g`]b`h`c`U`X`X`f`Y`g`g`g`d`Y`W`Z`W`f`Y`g`Y`Y`U`f`W`X`h`c`d`]W`g`"
- )`"G`h`X`Y`b`h`g`U`b`U`m`g`Y`Z`f`Y`d`c`f`h`U`b`X`]b`H`Y`d`f`Y`h`Z`]b`X`]b`[`g`
- \*`"G`h`X`Y`b`h`g`"Y`U`f`b`h`c`X`Y`j`Y`f`V`c`b`W`i`g`]c`b`g`U`b`X`f`Y`V`c`a`a`Y`b`X`U`h`c`b`g`h`h`f`c`i`[`\`f`Y`d`c`f`h`]b`[`U`b`X`c`f`U`"X`Y`j`Y`f`m`"

HYUWX]b[ `GhfUHY[ ]Yg`

HYUWX]b[ `ghfUHY[ ]Yg`]bW`i`X`Y`V`c`b`gi`h`U`h`c`b`U`b`X`g`i`d`Y`f`]g`]c`b`a`Y`Y`h`]b`[`g`k`]h`h`m`ci`f`V`ci`fgY`V`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`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`h`m`ci`f`h`c`g`h`c`f`[`U`b`]g`U`h`c`b`Z`U`b`X`f`Y`d`c`f`h`]b`[`j`]U`h`h`Y`V`ci`fgY`U`g`g`Y`g`g`a`Y`b`h`g`"

## 5ggYgga Ybh

H\Y`Zcfa Uħ`Yb[ ĤžUbX`gWēdY`cZU`Ugg][ ba Ybhg`]g`Zc`bY[ cĤUĤcb`VYĤk`YYb`mēi`žmēi`f`U[ fYYX!i`dcb`]bhYfbg\]d`gi`dYfj`]gcf`UbX`mēi`f`cgĤcf[ Ub]gUĤcb`"A`cfY`[ i`]XUbW`k`]`VY`[ ]`Yb`]b`Wēbgi`ĤUĤcb`a`YYĤb[ g`YUfm]b`ĤY`HYfa`k`]Ĥ`mēi`f`gi`dYfj`]gcf`UbX`cgĤcf[ Ub]nUĤcb`"

## 5ggYgga YbhHUg\_g`

5ggYgga YbhHUg_	K`Y][ \h	8i`Y`8UĤ	GĤi`XYbh@YUfb]b[`C`i`hWēa`Yg`5ggYggYX
:`]bU`F`Ydcfh	*`\$i	B`ch5dd`]WUV`Y	`ž(ž)ž*
C`fU`dfYgYbhUĤcb`cZfYgi`Ĥg`UbX`Z]bX]b[`g`cZ]bhYfbg\]d`dfc`YWĤ	&\$i	B`ch5dd`]WUV`Y	)ž*
ĤbhYfbg\]d`fYgYUfW`Vf]YZ	%)\$i	B`ch5dd`]WUV`Y	%)ž&
ĤbhYfbg\]d`8`]Ufm	%)\$i	B`ch5dd`]WUV`Y	%

## 5ggYgga Ybh8YĤ]`g

5ggYgga Ybh%`:`]bU`F`Ydcfh

GĤUfhXUĤ. B`ch5dd`]WUV`Y

8YĤ]`g.:`]bU`fYdcfhXYĤ]`]b[`U]a`gžgWēdYž`a`YĤcXgžUWĤ]`]ĤYg`WēbXi`WĤXžfYgi`Ĥg#Z]bX]b[`gžfY`Y]`Ubh`]ĤUfĤi`fYžUbX`fYWēa`a`YbXUĤcbg`Zc`f`ĤY`cf[`Ub]nUĤcb`"

F`Yj`]Yk`VmWēi`fgY`Wēbj`Ybcf`UbX`Wēa`a`Ybhg`Zc`a`cf[`Ub]gUĤcb`gi`dYfj`]gcf`"

5XX]ĤcbU`XYĤ]`g.

D`YUgY`WēbĤUWĤU`[`ccX!`Z]h9bj`]fcba`YbhUbX`GcWYĤmUWUXYa`]WghUZZa`Ya`VYf`Ĥc`fYei`YghĤYmWē!`gi`dYfj`]gY`mēi`f`k`cf`\_k`]Ĥ`mēi`f`cgĤcf[`Ub]gUĤcb`"

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

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

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

GĤUfhXUĤ. B`ch5dd`]WUV`Y

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

8YĤ]`g.C`fU`dfYgYbhUĤcb`cZ]bX]b[`g`Ĥc`UfXg`YbX`cZ]bhYfbg\]d`UfĤbYf`UbX`Wēbj`Ybcf`Wēa`a`YbhUbX`Ĥ]g`dfcj`]XYg`Ugg]gĤUbW`k`]Ĥ`Z]bU`fYdcfhWēa`d`YĤcb`"

5XX]ĤcbU`XYĤ]`g.

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

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

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

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

GHUfhXUH` . Bch5dd`]WVY

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

5XX]hc]cbU`XYHU]`g.

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`  
\cghicf[ 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`  
HYfa "

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

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

5ggYgga Ybh( . `bHYfbg\]d`8]Ufm

GHUfhXUH` . Bch5dd`]WVY

8YHU]`g. `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]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\`cghicf[ Ub]gUhc]b`UbX` ]bHYfbg\]d`gi dYfj ]gcf

Hi fb]hb`gYH]b[ . H\]g ]g`bchU`Hi fb]hb`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`

8UhY	HmdY	7cbhYbh
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`XYhYa ]bYX`]b`bY[ ch]U]cbg VYhk YYb`cgchcf[ Ub]gU]cbž`mci ž`UbX`mci f`U[ fYfYX! i`dcb`UWXYa ]WghUZZ]bhYfbg\]d`gi`dYfj`]gcf''5`c`hYf gWXYXi`]b[ `UbX'fYeI ]fYa Ybhg`Zck`Zca`h`]g`YUf`m YghUV`]g`a`Ybhcz`hY`]bhYfbg\]d`

## F Ygci fWg

### DfYgWf]VYX`F Ygci fWg`

H\Y`fYgci fWg`bYYXYX`Zcf`mci f`bhf`fbg\`d`k`j`VY`XYH`fa`]bYX`Vmi`h`Y`gW`d`Y`UbX`]bh`bhc`Z`h`Y`d`fc`Y`W`Z`UbX`  
Vmi`h`Y`f`Yei`]f`Ya`Y`b`hg`c`Z`mci f`c`ghcf`[`Ub`]g`U`h`c`b`UbX`mci f`U`[`f`Y`Y`X`!`i`d`cb`U`W`U`X`Y`a`]W`g`h`U`Z`]b`h`f`b`g`\`d`  
gi`d`Y`f`j`]g`c`f`Z`f`Y`U`h`X`h`c`mci f`h`c`d`]W`

### F YWca a YbXYX`F Ygci fWg

Mci`U`f`Y`Yi`d`Y`W`Y`X`h`c`Yi`Y`f`W`]g`Y`U`\`][`\`X`Y`[`f`Y`Y`c`Z`]b`]h`U`h`j`Y`]b`Z`]b`X`]b`[`mci f`]b`h`f`b`g`\`d`UbX`f`Y`g`Y`U`f`W`a`U`h`f`]U`g`  
f`Y`Y`j`Ub`h`Z`c`f`mci f`d`f`c`Y`W`

### 7 ci fgY`9j U`i U`h`c`b`UbX`8Yj Y`c`da Ybh

@]\_Y`U`A`9A`W`ci`fg`Y`g`Z`h`Y`U`d`d`f`c`U`W`h`c`h`Y`b`h`f`b`g`\`d`]g`X`Y`j`Y`c`d`Y`X`c`b`h`Y`V`U`g`]g`h`U`h`]b`X`Y`d`Y`b`X`Y`b`h`Ub`X`  
U`d`d`]Y`X`Y`U`f`b`]b`[`]g`\`][`\`m`j`U`i`Y`X`V`m`g`h`i`X`Y`b`h`g`Z`V`U`g`Y`X`c`b`d`U`g`h`Yi`d`Y`f`]Y`b`W`Ub`X`d`f`Y`j`]ci`g`Z`Y`X`V`U`W`\_`  
G`h`i`X`Y`b`h`g`\`U`j`Y`U`g`c`Yi`d`f`Y`g`g`Y`X`g`f`c`b`[`]b`h`f`Y`g`h`]b`h`Y`Yi`h`f`b`U`  
W`ca`a`i`b`]m`#`c`j`Y`f`b`a`Y`b`h`#`B`;`C`#`b`X`i`g`l`f`m`Yi`d`Y`f`]Y`b`W`h`U`h`h`Y`b`h`f`b`g`\`d`c`Z`Y`f`g`"

Gi Va ]gg]cb'cZ5ggYgga YbhiHUg\_g

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

Ẓmci YbWci bHyf'U'dfcV'Ya 'k \Yb'UHyYa 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] 'HyYa 'cb'YI HyfbU'Hy'hygi ddcfh4 i bgk "YXi "Ui "'Gi ddcfh  
\ci fg'UfY', .\$\$Ua '—%\$.\$\$da 'cb'k YY\_XUmg'UbX'-. .\$\$Ua '—') .\$\$da 'cb'k YY\_YbXg'f1 \*) 'XUmg'U'mYUf2" 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'mZcf'Ub'YI Hybg]cbž'Vi hmc i  
a i ghfYhU]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'jW]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`U`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\]bZcfa Uh\]cb#dfc`h`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"