HfU[]W:]fY']b'Dcfh'7\Uf`chhY.'9`YWhf]WU` : Ui `h'7`U]a g'Hk c'@]j Yg

 $5 \text{ fY WY b h Y Y Whf] WU ` ZU] ` i fY ` WU i gY X ` U ` hfU [] W Z] fY `] b ` D c fh \\ 7 \text{ Uf ` c hhY $\check{z}': ` c f] X U \check{z}' fY gi ` h] b [`] b ` hk c ` ZU hU `] h] Y g ` U b X ` gY j Y fU `] b ' i f] Y g "$



Dcfh'7\Uf`chhYž: `cf]XUž'I G5'!'5'hfU[]W]bW]XYbh'i bZc`XYX']b
Dcfh'7\Uf`chhYž: `cf]XUž'cb'A Um'&\$ž'k\Yb'U'\ci gY'Z]fY'WU]a YX'h\Y
`]j Yg'cZ'hk c'fYg]XYbhg'UbX'`YZh'h\fYY'ch\Yfg'Wf]h]WU``m']b'f fYX"
5\W\cfX]b['hc': cl (Bck ž']bj Ygh][Uhcfg'Zci bX'h\Uh'h\Y'Z]fY'k Ug
][b]hYX'Vm'Ub'Y`Y\Mf]\W\`ZU]`i fYž'gdY\M]Z]\W\``m' Y`Y\Mf]\W\``Uf\M]b[
c\W\ff]b[']b'h\Y'\Uhh]\W'5h'h\Y'h]a Y'cZ'h\Y'V`UnYž'Y][\h']bX]j]Xi U`g
k YfY'fYg]X]b[']b'h\Y'\ca Yž'UbX'h\Y'`\U_'cZ'gUZY'\\cbX]h]cbg'\Ug
fU]gYX'gYf]ci g'ei Ygh]cbg'U\ci h'h\Y'dfcdYfhmg'a UbU[Ya Ybh\]ghcfm"

H\Y'XYWYUgYX'gi ZZYfYX'gYj YfY'Vi fb'UbX'ga c_Y']b'\f|Yg\z'k]h\'cbY]bX]j]Xi U`'U`gc'gi ghU]b]b['W\Ygh']b'\f|Yg'UbX'h\Y'ch\Yf'\Uj]b[]b'\f|Yg'gdfYUX'UWfcgg'a i `h]d`Y'VcXm'dUfhg"'H\]g'\YUfhVfYU_]b[

 $\label{thm:linear} Yj\ Ybh'\][\ \][\ \ h\]b'\ ca\ Ygž'YgdYW]U``mh\ cgY']b'dccf'WcbX]h]cb''$

5 <]ghcfmcZBY[YWh

H\]g Dcfh7\Uf`chY`\ca Y`\UX`U`WcbWYfb]b[`\]ghcfmcZ`WcXY
YbZcfWYa Ybh'Wca d`U]bhgžgi [[Ygh]b[`]h'a][\h'\Uj Y`VYYb`U
\cUfXYf g`fYg]XYbWY`Z]``YX`k]h\`g][b]Z]WUbh'XYVf]g`]bg]XY`UbX`ci h"
\(\div \text{ZUWhz'h\YfY`\Uj Y`VYYb`Zci f`UVUhYa Ybh'UWh]cbg`hU_Yb`g]bW\\
\&\$%-\"`7i ffYbh`mz'h\Y`Wci bhm`\Ug`]ggi YX`U` 7YUgY`UbX`8Yg]gh
\cfXYfz'k\]W\`U``ck g`Zcf`ghf]Wh`]bgdYWh]cbg`UbX`WYUbi d`YZZcfhg`Vm
\WcXY`YbZcfWYa Ybh"`H\]g`cfXYfz'gh]```]b`YZZYWh`g]bW'`\&\$&&z`k]``
fYa U]b`Zcf`Z]j Y`mYUfg"

@cWU``cZZ]W]U`g`UfY`bck `Wcbg]XYf]b[`XYa c`]g\]b[`h\Y`Z]fY!XUa U[YX ghfi Whi fYž'Vi h`gi WX`UWh]cbg`k]```cb`m`dfcWYYX`cbWY`h\Y`cb[c]b[Z]fY`]bj Ygh][Uh]cb`WcbWi XYg"`H\Y`X]fY`WcbgYei YbWYg`cZ`hYbUbh]b[\ca Yg`h\Uh``UW_`dfcdYf`a U]bhYbUbWY`g\ci `X`bch`VY`cj Yf`cc_YX/h\Ym`Wca Y`k]h\`U`fYU``Wcgh`hc``]ZY`UbX`gUZYhm"

H\Y'6fcUXYfD]WhifYcZ'9`YWhf]WU`:]fYg

 $9`Y Whf]WU``Z]fYg`dcgY`U`g][b]Z]WUbh`f]g_`UWfcgg`h\Y`Wcibhfmž`Ug\\Yj]XYbWYX`Vm`ghUh]gh]Wg`Zfca`h\Y`I "G":]fY`5Xa]b]ghfUh]cb"`H\Y&$&'`bUh]cbU``Ygh]aUhYg`g\ckYX`&'~ž+$$`fYg]XYbh]U``Z]fYg`WUigYXVm`Y`YWhf]WU``aU`ZibWh]cbgž``YUX]b[`hc''$)`XYUh\g`UbX`,$$]b^1f]Yg"`H\Y`Wcgh`cZ`h\YgY`Y`YWhf]WU``ZU]`ifYg`UXXg`id`hc`UghU[[Yf]b[``%")`V]``]cb']b'dfcdYfhm`XUaU[Y`UbbiU``m"$

9`YWhf]WU``Z]fYg`UfY`cZhYb`hf][[YfYX`Vm`]ggi Yg`gi W\`Ug``ccgY`k]fYgž cj Yf`cUXYX`W]fW']hgž`cf`ZUi`hm`ci h`Yhg"`H\Y`H]a VYfg]```fYdcfh fYj YU`g`h\Uh`UVci h`(*ž+\$\$`Y`YWhf]WU``Z]fYg`cWW'f`Yj Yfm`mYUfž fYgi`h]b[`]b`Uddfcl]a UhY`m`'-\$`XYUh\g`UbX`%ž''\$`W]j]`]Ub`]b^if]Yg" 5`Ufa]b[`mž`U`a cgh`%'ı `cZ`U```\ca Y`Z]fYg`ghYa `Zfca `Y`YWhf]WU` a U`Zi bWh]cbgž`df]a Uf]`m``]b_YX`hc`gmghYa g``]_Y`ci h`Yhg`UbX gk]hW\Yg"

$K \ Yb \ 8c \ 9 \ YWhf]WU :]fYg \ Ghf]_Y3$

#bhYfYgh]b[`mžh\Y`a U^cf]hmcZ'Y`YWhf]WU``Z]fYg`g\ck 'U`ghf]_]b[
gYUgcbU``dUhhYfb"'A cgh`]bW]XYbhg`cWWi fiXi f]b[`h\Y`Wc`XYf`a cbh\gž
dUfh]Wi``Uf`m`Zfca 'Bcj Ya VYf`hc': YVfi Ufmž'Xi Y`hc']bWfYUgYX
\YUh]b[`i gY`UbX`\c`]XUm`UWh]j]h]Yg"'Bch`cb`m`Xc'h\Ym`dcgY`f]g_g
h\fci [\ci h'h\Y`mYUfž'Vi h'Wfi W]U``mž'h\Y`XUb[Yf'dYU_g`VYhk YYb'(
DA 'UbX', 'DA "'MYhž'h\Y'\][\Ygh'ZUhU`]h]Yg`hYbX`hc'cVWi f']b'h\Y'Yj Yb
XUf_Yf`\ci fg`cZ'a]Xb][\h'hc', '5A "

5g'k Y'fYZYWh'cb'h\]g'fYW'bh'hfU[YXm']b'Dcfh'7\Uf`chhYž']h'gYfj Yg Ug'U'ghUf_'fYa]bXYf'cZ'h\Y']a dcfhUbW'cZ'UX\Yf]b['hc'gUZYhm ghUbXUfXg']b'ci f'\ca Yg'':]fY'gUZYhm']bgdYWh]cbg'UbX'fYa YX]Uh]cb UfY'bch'a YfY`m'U'Vi fYUi WfUh]WZcfa U`]hm/'h\Ym'UfY'YggYbh]U`'hc gUZY[i UfX]b['`]j Yg''H\YfY g'gca Yh\]b['hc'VY'gU]X'Zcf'h\Y'UXU[Yh\Uh'dfYj Ybh]cb']g'VYhhYf'h\Ub'W' fYž'UbX'Ybgi f]b['ci f Ybj]fcba Ybhg'UfY'gYW' fY'g\ci `X'bYj Yf'VY'cj Yf`cc_YX''

8 Y hU]`g	
Cfh	Dcfh [·] 7\Uf`chhYž [·] : `cf]XUž [·] I G5
EiY``Yb	• k k k "Zcl (bck "Wca
	• k k k "i gZU"ZYa U"[cj
	• h]a VYfg]``"Wca

6 Y gi W Y b 'G | Y 'i b g 'U i Z 'a Y | b ! k | Y b "b Y h