



7ci fgY Cj Yfj]Yk

GHJZZ7cbHJWh8YHJ]`g

7cbj Ybcfg

BUa Y	9a U]`	5j U]`UV]`]lm	@cWUh]cb	D\cbY
F]WkUfX'GhiYhn	f"ghi Ym4 i bgk "YXi "Ui			

@YWhi fYfg

BUa Y	9a U]`	5j U]`UV]`] h m	@cWUh]cb	D\cbY
Fih:]g\Yf	fi h\"Zg\Yf4 i bgk "YXi "Ui			
6UfUb^M]`X]n	VUfUb"mj`X]n4 i bgk "YXi "Ui			
>Ua Yg < UmYg	<u>^"Y"\UmYg4 i bgk "YXi "Ui</u>			
FcVYfh7UfY	f"WUfY4 i bgk "YXi "Ui			
9`bUn'≢UbbYn\UX	Y"]fUbbYn\UX4 i bgk "YXi "Ui			

GWkcc~7cbhJWh~abZcfa Uhlcb

<u>9b[]bYYf]b['Gh'XYbhGiddcfhGYfj]WYg'-</u>'H\Y'BiWYig'!'Ybfc`a Ybhž'dfc[fYgg]cb'W\YW_gž'WUg\'fYeiYghgž WtifgY']ggiYg'cf'dfc[fUa!fY`UhYX'eiYf]Yg'

9b[]bYYf]b['\dag{b}Xi ghf]U\'HfU]b]b[_\dag{b}-\dag{b}Xi ghf]U\'hfU]b]b['ei Ygh]cbg'

LBGK Gh Xm5VfcUX - gh XmUVfcUX gh XYbhYbei]f]Yg fZcf]bVci bX gh XYbhgŁ

<u>I BGK '91 WXUb[Y</u>'-gh XYbhYl WXUb[Y'Ybei]f]Yg'flcf']bVci bX'gh XYbhgl'

LBGK: i h fY'Gh XYbhg'-'dchYbhJU``gh XYbhYbei]f]Yg'Y"["'UXa]gg]cbgž'ZYYgž'dfc[fUa gž'WfYX]hhfUbgZYf'

D\cbY.

fŽ*%&Ł-',),)\$\$ - Bi WYi g Gh XYbh<i V

fŽ*%'&L'-',) '+**%'-'9b[]bYYf]b['=bXi glf]U``HfU]b]b['

fŽ*%&£'-',) " %+- '-1 BGK 'Gh Xm5VfcUX'UbX'1 BGK '91 WXUb[Y'fZcf']bVci bX'gh XYbhg£'

7ci fgY 8YHJ] g

$I b hg c Z 7 f Y X h^*$

Gi a a UfmcZh\Y 7ci fgY

H\Y'Wti fgY'YbUV'Yg'Yb[]bYYfg'hc'UbU'mgY'UbX'XYg][b'gi ghU]bUV'Y']bZfUghfi Whi fY'hc'gi ddcfhih\Y'bYYXg cZi fVUb'UbX'fY[]cbU'`YWtbca]Yg'UbX'dcdi `Uh]cbg"'=iVi]'Xg'cb'UbX'Udd`]Yg'h\Y'WtbW'dhg'`YUfbYX']b]bhfcXi Whcfmhcc`gz'k UhYfz'hfUbgdcfh'UbX'Yb[]bYYf]b['cdYfUh]cb'Wti fgYg']b'GhU[Yg'%hc'' "'=idfcj]XYg'Y]h\Yf Ub'i fVUb'cf'fY[]cbU'`WtbhYI hhc'h\Y'd`Ubb]b['UbX'XYg][b'cZ]bZfUghfi Whi fY']b'h\Y'UfYUg'cZk UhYf'UbX'k UghYa UbU[Ya Ybhz'hfUbgdcfhgYfj]Wygz'YbYf[mgi dd`mUbX'X]ghf]Vi h]cb/UbX']bhfcXi Wyg'd`Ubb]b['a Yh\cXg'hc YbUV'Y'gmghYa 'h\]b_]b['hc'XYg][b'Zfca 'a UWfc'hc'UggYhgdYW]ZJWgWU'Yz'gc'h\Uhgi ghU]bUV'Y'ci hWta Yg'UfYYbUV'YX'Zcf'i fVUb'UbX'fY[]cbU'`Wta a i b]h]Yg"

H\Y`Wci fgY`Wcj Yfg`h\Y`gmghYa `XYg][b`cZ]bZfUghfi Whi fYzgdYWJZJWU``m'ZcWig]b[`cb.

- K UhYf gmghYa g
- HfUbgdcfhigmghYa g
- 9bYf[migmghYa g
- A UhYf]U`a UbU[Ya YbhiqmqhYa qž'dUfh]W `Uf`mfY`UhYX'hc'k UqhY'UbX'k UqhYk UhYf
- D`Ubb]b[']bZi YbWYg'cb'fY[]cbU`'UbX'i fVUb']bZfUglfi Wi fY

•

5ggYgga Ybh

Ghi XYbhg`k]``i bXYfhU_Y`U'j Uf]YhmicZ]bX]j]Xi U``UbX`[fci d`UggYgga YbhihUg_g`h\UhiUfY`UggcW]UhYX`k]h\Wti fgY`cVYWfj Yg"

; fci dgˈk]h\ Zci fˈa Ya VYfgˈk]``VYˈgY`ZgY`YWhYXʻi g]b[[fci dgˈcbˈA ccX`Y'VmYbXˈcZK YY_'%"

: cf^[fcid'UggYggaYbh]hYagžcb`mcbY'giVa]gg]cb^]g'U``ckYX'hc'VY'giVa]hYX'dYf^[fcid'fMcif'Z]fghgiVa]gg]cb']g'mcif'Z]bU``giVa]gg]cbt"'`5```UggYggaYbhgiVa]gg]cbg'k]```VY'h\fci[\`AccX`Y'UbX#cfHifb]h]b"

5ggYgga Ybh'Wca dcbYbhgž'h\Y'a Uf_g'Ugg][bYX'hc'YUW\'hUg_ž'UbX'h\Y'XUhYg'cZgi Va]gg]cb'UfY'gYh'ci h

J]XYc'dfYgYbhUhjcb'cb'h\Y']bhY[fUhjcb'cZX]gWjd`]bY'gi V'YWia UhhYf'k]h\'h\Y'gcWjU`žW`hifU`'UbX#cf Ybj]fcba YbhU``VUW_[fci bX'Zcf'WUgY'ghiXm`cWUhjcb"

5ggYgga Ybh'Wf]hYf]U

; fci d'UggYgga Ybhj]XYc'dfYgYblUljcb fbYY'A ccXY Zcf'XYlU]`gŁ

5XX]h]cbU`XYhJ]`q

DYYf'a Uf_]b['cZ[fci d'j]XYc'dfYgYblUlljcbg'k]``c\\VV f'cb'Hi YgXUm, #\\&\VYlk YYb'(!*da 'fk YY_'-\!"

5```[fci d'a Ya VYfg'UfY'fYei]fYX'hc'UhhYbX'Zcf'gUhJgZUWhcfmWca d'YhJcb'cZh\]g'UggYgga YbhihUg_"

5ggYgga Ybh' . Dfc YWnA UbU[Ya YbhUbX Dfc ZYgg]cbU`8Yj Y`cda Ybh

GhJfh'XUhY. % # #&\$&&

5ggYgga Ybh`Yb[h. Dufh5!F YdcfhUbX[fcid]bhYfj]Yk /Dufh6!' 'Cb`]bYa cXi `Yg`fgYY'A ccX`YŁ 8i Y`XUhY. Dufh5!'% #%#&\%) - 'DA /Dufh6!'gYY'A ccX`Y A Uf_g`fYh fbYX. 'K]h\]b'' 'k YY_g

DUfh5 ! Dfc YVMa UbU[Ya YbhfYdcfhcb h\Y a UbU[Ya YbhcZUggYgga YbhHJg_ Vm[fci dg fgYY A ccX`Y Zcf XYHJ]gŁ

DUfh6 ! DfcZygg]cbU`XYj Y`cda Ybh'UggYgga Ybh'HUg_g'fgYY'A ccX`Y Zcf'a cXi `Y'XYHU]`gŁ

H\]g`Ugg][ba Ybh]g`gi Va]hhYX`h\fci [\`Hi fb]h]b`UbX`gh XYbhg`Wb`gYY`Hi fb]h]b`g]a]`Uf]hmifYdcfhg"

5ggYgga YbhWf]hYf]U

DUffi5: Fri d'UggYgga Ybhdfc YWia UbU[Ya YbhfYdcfhUbX [fci d']bhYfj]Yk fXi f]b[k YY_': #&

DUfh6 ! '-bX]j]Xi U`cb[c]b['dfcZ/gg]cbU`XYj Y`cda Ybha cXi `Yg`fGYY`A ccX`Y 'Zcf'8YhU]`gŁ"

5XX]h]cbU`XYhJ]`g

DUfh5 !; fci d`]bh/fj]Yk g`k]``c\\\ f`cb'Hi YgXUm&&#\%#&&`fk YY_'\%\£"

5```[fci d'a Ya VYfg'UfY'fYei]fYX'hc'UhYbX'Zcf'gUh]gZUWcfm'Vca d`Yh]cb'cZh\Y'UggYgga Ybh'hUg_"

5qqYqqa Ybh(. HYW\b]WU`F Ydcfh

GhUfhXUhY. %&# #&\$&&

5ggYgga Ybh`Yb[h\.'%\$'dU[Yg'k f]hhYb'fYdcfhd`i g'5ddYbX]l

8i Y'XUhY. % #%#&\$&&*%%) - DA

A Uf_g fYh fbYX. K]h\]b (k YY_g

HYWXb]WU``UggYgga Ybhcb'Y]h\Yf'k UhYfžk UghYž'hfUbgdcfhcf'YbYf[mZcf'WJgY'gh Xm'cWJh]cb"

H\]g`Ugg][ba Ybh]g`gi Va]hhYX`h\fci [\'Hi fb]h]b`UbX`gh XYbhg`Wb`gYY`Hi fb]h]b`g]a]`Uf]hmfYdcfhg"

5ggYgga Ybh'Wf]hYf]U

 $\pm X]j\]Xi\ U``UggYgga\ YbhifgYY`A\ ccX`Y`Zcf`XYhU]`gŁ$

5 http://bxubwww.Fyei]fyaYbhg

 $\hbox{Ghi XYbhg'UfY'ghfcb[`m'YbWc'i fU[YX'hc'UhhYbX'U```WUggYg'UbX'fYj]Yk'``YWhi fY'fYWc'fX]b[g''' } \\$

7ci fgY'GWXYXi `Y

 $\label{thm:condition} $$H\Y'HUV'Y'cZ'YWN fYg'UbX'k cf_g\cdg'Zcf'YUWX'k YY_z']bX]WUHJb[''HXY'hcd]Wg'UbX'HXY'bUa Yg'cZdfYgYbHYf]bj c'j YXz'UggYgga YbHk cf_g\cdgz'[fci d'Wcbgi `HUHJcb'k cf_g\cdgz'UbX'[fci d'UbX']bX]j]Xi U''UggYgga YbH UWHJ]HYg''$

f&%#%%#&&Ł	⇒bhYfj]Yk "fU```ghi XYbhgŁ
	5***8 Um

Gi Va]gg]cb cZ5ggYgga YbhHUg_g

D`YUgY`fYZYf`hc`h\Y`A ccX`Y`dU[Y`cZh\Y`Wci fgY`Zcf`Z fh\Yf`[i]XUbW\`cb`UggYgga Ybhigi Va]gg]cb"

I BGK `\Ug`U`ghUbXUfX``UhY`gi Va]gg]cb`dYbU`hmcZ

•)ı 'dYf'XUmž'Zcf'U``'UggYgga Ybhg'k \YfY'U'dYbU'hm'Udd`]Ygž'WUddYX'Uh'Zjj Y'XUmg'f1%&\$`\ci fg\z'UZhYf k\]WX'U'ghi XYbhWUbbchgi Va]h'Ub'UggYgga Ybhž'UbX'bc'dYfa]hhYX'j Uf]Uh]cb"

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

6Yk UfY "5b" Ugg][ba Ybhh\Uh]bWi XYg"d`U[]Uf]gYX"a UhYf]U``k]```fYWY]j Y"U"\$ı ': U]`žUbX`ghi XYbhg`k \cd"\U[]Uf]gY\"a UmZU]``h\Y'Wci fgY"'Ghi XYbhg`k \cd"\U[]Uf]gY\"UfY\"U`gc"`]UV`Y'hc"X]gW]d`]bUfm'UWf]cbž]bWi X]b[YI Wi g]cb'Zfca 'Ybfc`a Ybh'

 $D`U[]Uf]ga ~]g'hY'i gY'cZUbch\Yf'dYfgcb'g'k cf_'cf']XYUg'Ug']Zh\Ymk YfY'mci f'ck b'''K ~Yb']h]g'bYWYggUfmcf XYg]fUV'Y'hc'i gY'ch\Yf'dYcd'Y'g'a UhYf]U`'mci 'g\ci `X'UXYei UhY`mUW_bck `YX[Y'k \cgY'k cfXg'cf']XYUg'h\Ym$

5 WUXYa]W = DZcfa Uhjcb

:]bU`'9l Ua]bUh]cbg.

:]bU`YI Ua g`]b`H' `&\$&&`k]```VY`\Y`X`cb`]bY`VYlk YYb`&) h\`Bcj Ya VYf`!`, h\`8YWYa VYf`&\$&&`]bWi g]j Yž`UbX gi dd`Ya YbhJfmYl Ua g`VYlk YYb`-h\`!`% h\`>Ubi Ufm&\$&' `]bWi g]j Y"'Mci `UfY`fYei]fYX`hc`VY`Uj U]`UV`Y`cb h\YgY`XUhYg"`D`YUgY`Xc`bchhc`a U_Y`UbmdYfgcbU``cf`lfUj Y``UffUb[Ya Ybhg`Xi f]b[`h\]g`dYf]cX"'

57589A = 7.58J = 7.9

- ? YmiGtUZztc '7 cbtUWiZcf '5 WUXYa]W5 Xj]WY flc[']b 'k]th 'mci f 'n=8 'UbX dUggk cfXt '\text{htdg.#|btfUbYtiW| Yb["i bgk "YXi "Ui # YmlgtUZItc!WcbtUWiXi f]b[!mci f!gti X]Yg!Utli bgk
- <u>? Ymil_BGK_'8 UhYg'</u>! 'Y["'7 Ybgi g'8 UhYžYI Ua 'XUhYgž``UghiXUmhc 'Xfcd'U'Wci fgY'k]h\ci h UWUXYa]\#Z|bUbW]U```]UV]`]miYhW''
- 7 J 9B 'Ghi XYbhi=bhfUbYhrflc[']b 'k]h\ 'mci f'n=8 'UbX dUggk cfXŁ '\hadg.#|bhfUbYh'W| Yb["i bgk "YXi "Ui #ahi XYbh]bhfUbYh'
- Gh XYbh@ZY 'Uh7 J 9Bž]bWi X]b['Gh XYbh GcW]Yh]Yg. \(\frac{1}{2} \) Htdg. #k k k "i bgk "YXi "Ui #Yb[]bYYf]b[#M] \(\frac{1}{2} \)! UbX!Ybj]fcba YbHU\!Yb[]bYYf]b[#gh XYbH\]ZY \(\frac{1}{2} \)
- GdYV)JU``7 cbg]XYfUhjcb. \https://https://www.https://https://https://https://https://www.https://ht

<u>i</u>