

6Yf`]bYf': fY]VÀXYf']a 'Gca a Yf. 'BYi Y FY[Y`b'gcf[Yb'ZØf'DfchYghY

BYi Y`FY[Y`b`]b`6Yf`]bYf': fY]VÀXYfb`gcf[Yb`ZØf`Ÿf[Yf. 5i gk Y]gdZ]W\hi bX`Cb`]bY!H]W_Yhg`k YfXYb`U`g X]g_f]a]b]YfYbX`_f]h]g]Yfh"`\#\hhhdYh]h]cb]YfYb`X]Y`6UXY[\AghY°



#D'XYf'di `g]YfYbXYb' < Ui dhghUXh'6Yf`]b'gcf[Yb'X]Y'gca a Yf`]WXYb HYa dYfUhi fYb'ØVYf'' \$; fUX'ZØf'fY[Yg'HfY]VYb']b'XYb': fY]VÀXYfb" 8cWX'k Ug'U`g'YbhgdUbbhYf'HU['Ua 'GWXk]a a VYW_Yb'[Yd`Ubh'k UfžjYfk UbXY`h'g]WX'ZØf'j]Y`Y'6UXY[ÀghY']b'Y]b'i b`]YVgUa Yg 5VYbhYi Yf"'GY]h'X]YgYa '*J\f'a ØggYb'g]WX'6Ygi WXYf'b]WXh'bi f'a]h Y]bYa '@]WXhV]`XUi gk Y]g']XYbh]Z]n]YfYbž'gcbXYfb'gY\Yb'g]WX'Ui WX a]h'bYi Yb'FY[Y`i b[Yb'_cbZfcbh]Yfhž'X]Y'ZØf'fY]WX`]WX'I ba i h qcf[Yb"

± ZØbZ: fY]VÀXYfb XYf GhUXhž XUfi bhYf X]Y VY`]YVhYb
9]bf]W\hi b[Yb]b DUb_ck ž BYi _Ò``b i bX ? fYi nVYf[ž _ÒbbYb
GW\k]a a ZfYi bXY bi f bc W V]g %\$ T\f Ub XYb ? UggYb H]W_Yhg
Yfk YfVYb "K Yf X]YgY : f]gh j Yfd Ugghž]gh Ui Z C b`]bY!H]W_Yhg

Ub[Yk]YgYb"'8]YgY'FY[Y'i b['k i fXY'Y]b[YZØ\fhži a 'b]W\h'bi f'X]Y?cbhfc``Y'ØVYf'X]Y'6Ygi W\YfnU\`Yb'ni 'j YfVYggYfbž'gcbXYfb'Ui W\i a 'j Yfa i hYhYb'; Yk U`hUi ggW\fY]hi b[Yb']b'XYf'JYf[Ub[Yb\Y]hYbh[Y[Ybni k]f_Yb"

DfchYghY [Y[YbX]YbYiYbFY[Y`ib[Yb

8]Y'A U» bU\a Yb'ghc» Yb'YXcW\'Ui Z'a Ugg]j Y'?f]h]_'gY]hYbg'XYf
6UXY[AghY"'9]bY'; fi ddY'\Uh'VYfY]hg'Y]bY'Cb`]bY!DYh]h]cb
[YghUfhYhž'X]Y'a]hh`Yfk Y]`Y'%"-\$\$'I bhYfgW\f]ZhYb'[YgUa a Y`h'\Uh''
8]Y'\D]h]UhcfYb'Uf[i a Ybh]YfYbž'XUgg'X]Y'FY[Y`i b[Yb'ZØf
A YbgW\Yb'c\bY'?fYX]h_UfhYž'DUmDU`!?cbhc'cXYf'\DhYfbYhni [Ub[VYbUW\hY]`][YbX'g]bX"'8]Yg'ZØ\fY'XUni ž'XUgg'g]Y'j cb'Y]bYa
: fY]VUXVYgi W\'Ui g[YgW\`cggYb'k YfXYbž'k Ug']\fYf'A Y]bi b['bUW\Y]bYf': cfa 'j cb' 8]g_f]a]b]Yfi b['Ybhgdf]W\h''

 $: fY]VUX:Y]bZUWX:ZØf:U``Y: gc:`Ui:hYh:XYf:H]hY`:XYf:DYh]h]cbž:X]Y\\g]WX:X]fY_h:Ub:6Yf`]bg:<math>\oplus$ bYb!:i bX:GdcfhgYbUhcf]b:#]g:GdfUb[YffGD8\L:gck]Y:Ub:XYb:J cfghUbXgj cfg]hnYbXYb:XYf:6Yf`]bYf:6\AXYf! 6Yhf]YVY $Z:_{\infty}$ \UbbYg:?`Y]bgcf[$Z:_{\infty}$ f]WX:hYh":8]Y:#0]h]UhcfYb:ZcfXYfb:X]Y F\@W_bU\a Y:XYf:bYi:Yb:FY[Y`b:i bX:gYhnYb:g]WX:Z\@fY]bY:]b_`i g]j Y:fY]VUX_i `hi:fY]bZ:X]Y:U``Yb:cZZYbghY\h"

 $8]Y `6Yf`]bYf` 6 \grave{A}XYf! 6Yhf]YVY` \i [Y[Yb'j YfhY]X][Yb'X]Y$ $Y]b[YZ\emptyset \i fhYb'A U \i bU \i a Yb'i bX'VYn]Y \i Yb'g]W `Ui Z'X]Y$ $G]W \i Yf \i Y]hgVYXYb _Yb\check{z}'X]Y'ni `X]YgYb'Y'bXYfi b[Yb'[YZ\emptyset \i fh' \i UVYb'' @Ui h'Y]bYf`GdfYW \i Yf]b'gc```X]Y'5i gk Y]gdZ]W \i h' \i Y`ZYb\check{z}'J Yf[Y \ Yb' X]Y' < Ui gcfXbi b['VYggYf'ni 'fY[i `]YfYb\check{z}'k Ug'`YhnhYbX`]W XUni `X]Ybhž`XUg'6UXYYf`YVb]g'ZØf'U``Y'g]W YfYf'ni '[YghU`hYb'' \]$

<]bhYf[fØbXY ni f FY[Y AbXYfi b[</pre>

8]Y '9bhg\\Y]Xi b[žY]bY '5i gk Y]gdZ]\\Xhi bX 'X]Y '9]bg\\Xf\\h_i b[XYf'? UggYbnY]hYb 'Y]bni Z\\Q\fYb\z'k i fXY 'b]\\Xhi h'`Y]\\XhZYfh]['[Yhfc ZZYb" \div XYb'j Yf[Ub[YbYb '\d\\fYb'_Ua 'Yg']b 'Y]b][Yb': fY]\\AXYfb'ni [Yk U`hh\h][Yb'J cfZ\\`Yb\z'X]Y 'gck c\``6UXY[\AghY'U`g'Ui \\X A]hUf\Y]hYf']b '6YXf\\hb[b]g'\YfU\\XhYb" 8 Ug'\N]Y``XYf'FY[Y`i b[Yb']gh Yg\z'Y]bY'YbhgdUbbYbXYfY'5ha cgd\\AfY'ni 'g\\X\UZZYb\z']b'XYf'g]\\X

8 c W 'X]Y 'F Y U `]hÀh 'g]Y \ h 'Ub XY fg 'Ui g" '8]Y '6 Y XY b _Y b ž' X Ugg

A Y b g W Y b 'Ui Z[fi b X 'Z]b Ub n]Y ``Y f' c XY f' h Y W b]g W Y f' < Ø f XY b 'j c b

Y]b Y a ': fY]V U X V Y gi W 'Ui g[Y g W `c g g Y b 'k Y f X Y b ž' g W k]b [Y b ']b 'X Y b

Gh]a a Y b 'X Y f' ?? f]h] _ Y f' a]h" '8]Y g 'j Y f X Y i h`] W hž' X Ugg 'V Y] 'X Y f

I a g Y h n i b ['j c b 'G] W Y f \ Y]h ga U » b U \ a Y b 'Ui W 'X]Y 'N i [Àb [`] W _ Y]h

ZØ f'U` `Y '6 Y gi W Y f' V Y f Ø W _ g] W h][h 'k Y f X Y b 'g c ``h Y " '8 Y f 'G d U [U h

n k]g W Y b 'G] W Y f \ Y]h 'i b X ' \ = b _ `i g]j]h A h 'g W Y]b h Y]b Y

< Y f Ui g Z c f X Y fi b ['n i 'g Y] b ž' a]h 'X Y f' g] W 'X]Y 'G h U X h j Y f k U `h i b [

Ui g Y] b U b X Y f g Y h Y b 'a i g g"

±g[YgUa hˈg]bXːX]YʻbYi YbʻFY[Y`i b[YbʻY]bʻ_cbhfcj YfgYgʻH\Ya U
]bʻXYfʻ6Yf`]bYfʻ6ÀXYf`UbXgW.UZh" K À\fYbX Y]b][YʻX]YʻA U» bU\a Yb
Uʻgʻbchk YbX]['YfUW\hYbžʻgY\YbʻUbXYfYʻg]YʻUʻgʻ9]bgW.fÀb_i b[
]\fYfʻFYW\hYʻi bX∵ fY]\Y]hYb"′9gʻVʻY]VhʻUVni k UfhYbžʻk]YʻX]YʻGhUXh
Ui ZʻX]Yʻk UW\gYbXYʻ?f]h]_ʻfYU[]YfYbʻk]fXʻi bXʻcVʻŸbXYfi b[Ybʻ]b
XYfʻU_hi Y``YbʻFY[Y`i b['VYj cfghY\Yb"

=a $(6)W_dib_hXYf8]g_igg]cb$

8]Y'U_hi Y``Y'@U[Y']b'XYb'6Yf`]bYf': fY]VÀXYfb'fYZY_h]Yfh'VfY]hYfY
[YgY``gW\UZh`]W\Y'H\Ya Ybž'X]Y'g]W\'i a 'Ni [Ub['i bX'; `Y]W\\Y]h
XfY\Yb"'8]Y'8]g_i gg]cb'ØVYf'X]Y'bYi Yb'FY[Y`i b[Yb'_ObbhY
k Y]hfY]W\YbXY'5i gk]f_i b[Yb'Ui Z'X]Y'ni _ØbZh][Y'; YghU`hi b['j cb
OZZYbh`]W\Yb'GW\k]a a ghÀhhYb'\UVYbž'gck c\`']b'6Yf`]b'U`g'Ui W\']b
UbXYfYb'GhÀXhYb"'8]Y'6U`UbW'nk]gW\Yb'Y]bYa 'g]W\YfYb'I a ZY`X
i bX'XYf'Ni [Àb[`]W_Y]h'ZØf'U``Y'V'Y]Vh'Y]b'nYbhfU`Yg'9`Ya Ybhž'XUg
VY]'_ØbZh][Yb'9bhgW\Y]Xi b[Yb']a a Yf']a 'JcfXYf[fi bX'ghY\Yb
qc``hY"

6ÀXYf!6Yhf]YVY 'YfUfVY]hYhYb 'XUfUi Z\]b 'XUg'?cbnYdh'XYf
5i gk Y]g_cbhfc``Ybži a '≠XYbh]hÀhgj Yf]Z]_Uh]cb 'ni 'Yfa Ò[`]W\Yb 'i bX
i a 'g]W\Yfni ghY``Ybž'XUgg'j cf'Cfh'_Y]bY'i bYfk ØbgW\hYb

J Yf\U`hYbgk Y]gYb 'hc`Yf]Yfh'k YfXYb"'Ni XYa 'k i fXY'X]Y'FY[Y`i b[
j cb 'XYf'Dc`]nY]'i bX'g]W\Yf\Y]hgdc`]h]gW\Yb'5_hYi fYb']b 'XYf'GhUXh
i bhYfghØhnh"

JYfÀbXYfi b['XYf'6UXY[Yk c\b\Y]hYb']b 6Yf`]b

8]Y'U_hi Y'`Yb'ŸbXYfi b[Yb'\UVYb'Ui WX'h]YZYfY'K i fnY`b']b'XYb
g]WX'j YfÀbXYfbXYb'6UXY[Yk c\b\Y]hYb'i bX'XYa
: fY]nY]hj Yf\U`hYb']b'; fc>ghÀXhYb'''=b'XYb'``YhnhYb'>J\fYb'Yf`YVhY
X]Y'GhUXh'Y]bYb'5bgh]Y['Ub'6Ygi WXYfb']b'`OZZYbh']WXYb': fY]VÀXYfb''
9]bY'5bU`mgY'j cb'I a ZfU[Yb'ni ': fY]nY]hj Yf\U`hYb'nY][hž'XUgg'XYf
6YXØfZb]g'bUWX'9f\c`i b[']a''i fVUbYb'FUi a '_cbh]bi]Yf`]WX
[Ygh]Y[Yb']gh'''=bgVYgcbXYfY'X]Y'7CJ=8!%-!DUbXYa]Y'\Uhij]Y`Y
A YbgWXYb'XUni 'j YfUb`Ugghž'a Y\f'NY]h']a'': fY]Yb'ni 'j YfVf]b[Ybž
k Ug'ni 'Y]bYa' ØVYfZØ``hYb': fY]nY]hcfh'ZØ\fYb'_Ubb'''8]Y
GhUXhj Yfk U`hi b['g]Y\h'g]WX'XU\Yf'[Ynk i b[Ybž'A U>bU\a Yb'ni
Yf[fY]ZYbž'i a''Y]bY'Ub[Ya YggYbY'Bi hni b['XYf'6ÀXYf'ni
[Yk À\fYb"

 $9]bY'XYi hgWX`UbXk Y]hY'Ghi X]Y'VY`Y[hž'XUgg']a "$J\f'&$&' "X]Y : fY]VUXVYgi WXY']b "ghÀXh]gWXYb"; YV]YhYb"]a "JYf[`Y]WX'ni "&$%-i a "Yhk U'&) ı "[Ygh]Y[Yb'g]bXž'k Ug'Ui Z'Y]b "ghUf_Yg'6YXØfZb]g'bUWX Gdcfhii bX': fY]nY]h']b "XYf'B Uhi f'ni fØW_ni ZØ\fYb']gh'fGhUh]ghUŁ" 8]Yg Vf]b[h'YXcWX'Ui WX'<YfUi gZcfXYfi b[Yb'a]h'g]WXž']bgVYgcbXYfY']b 6Yni ['Ui Z'X]Y'G]WXYf\Y]h'i bX'XYb'U``[Ya Y]bYb'Ni ghUbX'XYf 9]bf]WX hi b[Yb"'I a "X]YgYb'5bgh]Y['ni 'VYk À`h][Yb'i bX'[`Y]WXnY]h][X]Y'G]WXYf\Y]h'ni 'Yf\O\Ybž'gWXY]bYb'X]Y'6Yf`]bYf'6ÀXYf!6Yhf]YVY X]Y'bYi Yb'J cfgWXf]ZhYb'U`g'bchk YbX][Yb'GWXf]hh'ni 'VYhfUWXhYb"$

8]Y'5i gk]f_i b[Yb'Ui Z'VYbUW\hY]`][hY; fi ddYb

8]Y'?cbhfcj YfgYb'i a 'X]Y'bYi Yb'FY[Y`b'gd]Y[Y`b'YXcWX'Y]bY

h]YZYfY'[YgY``gW\UZh`]W\Y': fU[YghY``i b['k]XYf"'8]Y'?f]h]_ž'XUgg'X]Y
FY[Y`i b[Yb'VYbUW\hY]`][hY'; fi ddYb'Ui ggW\`]Y»Yb'_ObbhYbž'k]fZh
Y]b'@]W\h'Ui Z'X]Y'X][]hU`Y'?`i Zhii bX'XYb'Ni [Ub['ni 'a cXYfbYb
NU\`i b[ga Yh\cXYb"'\dgVYgcbXYfY'A YbgW\Yb'a]h'[Yf]b[Ya
9]b_ca a Yb'cXYf'VY[fYbnhYa'Ni [Ub['ni 'HYW\bc`c[]Y'ghY\Yb
i bhYf'8fi W_"'9]bY'_Øfn`]W\'Xi fW\[YZØ\fhY'I a ZfU[Y'Yf[UVž'XUgg
Yhk U'%) i 'XYf'6Yf`]bYf'<Ui g\U`hY'_Y]b'fY[Y`a À»][Yb'Ni [Ub[
ni a '\ddot hYfbYh'\UVYb' 'Y]b': U_hž'XYf'X]Y'; Ø`h][_Y]h'XYf
Ÿi »Yfi b[Yb'XYf'DYh]h]cb'i bhYfghØhnh''

8]Y'6Yf`]bYf'6ÀXYf!6Yhf]YVY'g]bX'g]W\'XYf'<YfUi gZcfXYfi b[VYk i gghž'Yg'V`Y]Vh'YXcW\'UVni k UfhYbž'k]Y'Ui Z'X]Y'6YXYb_Yb fYU[]Yfh'k]fX'i bX'cV'a Ò[`]W\Yfk Y]gY'U`hYfbUh]j Y'@Ògi b[Yb']b 9fk À[i b['[Ync[Yb'k YfXYb"'9]b'8]U`c['nk]gW\Yb'XYb'6YhfcZZYbYb i bX'XYb'J YfUbhk cfh`]W\Yb'_ÒbbhY'\Y`ZYbž'X]Y'6YXYb_Yb'XYf 6Øf[Yf'VYggYf'ni 'UXfYgg]YfYb"

 $: \emptyset f `X] Y `Ni _i b Zh `] gh `Yg `Yb hg W X Y] X Yb X ž `X Ugg `X] Y `Gh U X hj Y fk U `hi b [i b X `X] Y `6 Å X Y f! 6 Y hf] Y V Y `[Ya Y] b g Ua `@ Ogi b [Yb `Z] b X Y b ž `X] Y `X Y b 6 Y X Ø f Z b] g g Y b `U ` `Y f `6 Ø f [Y f `[Y f Y W h `k Y f X Y b `i b X `[`Y] W n Y] h] [`X] Y G] W X f \ Y] h `i b X `X Y b `: f] Y X Y b `] b `X Y b `: fY] n Y] h g h A h Y b `[Y k A \ f `Y] g h Y b "$

B 5;

8 Y hU]`a

6 Y gi W Y b 'G] Y 'i b g 'U i Z 'a Y] b ! V Y f `] b "b Y h