

 $9bhXYW_Yb^G]Y^X]Y^J]Y^ZU^h^DUb_ck\ g.\ 'j\ cb^'\]ghcf]gWXYb <][\ \ '][\ \ hg^ØVYf^_i\ \]bUf]gWXY^?Ogh^]WX_Y]hYb^V]g^\]b^ni ^?i bghž^i ^hi f'i bX^[fØbYb^CUgYb'' <math>\rightarrow$ fY^5VYbhYi Yf^k UfhYb^



K]``_ca a Yb']b'DUb_ck žY]bYa 'XYf'j]Y`ZÀ`h][ghYb'i bX
WX Ufa UbhYghYb'GhUXhhY]`Y'6Yf`]bg°'CV'Xi 'Y]b'9]b\Y]a]gWXYf'V]ghž
XYf'gY]bY'BUWXVUfgWXUZh'VYggYf'_YbbYb`YfbYb'a ÒWXhYž'cXYf'Y]b
FY]gYbXYfž'XYf'Ui Z'XYf'Gi WXY'bUWX'j YfghYW_hYb'¾k Y`Yb']gh'
DUb_ck '\Uh'ZØf'YXYb'; YgWXa UW_'Yhk Ug'ni 'V]YhYb"'A]h'gY]bYb
UVk YWXg`i b[gfY]WXYb'GhUXhhY]`Ybž'X]Y'U``Y']\fYb'Y][YbYb
7\UfU_hYf'i bX'7\Ufa Y'VYg]hnYbž'_Ubbgh'Xi 'XUg'Ui h\Ybh]gWXY
@YVYb'XYf'6Yf`]bYf'\Ui hbU\'Yf`YVYb"

DUb_ck 'V]YhYh'b]W\h'bi f'Y]bY'ZUgn]b]YfYbXY'A]gW\i b['Ui g ; YgW\]W\hY'i bX'A cXYfbY\z'gcbXYfb'Ui W\'Y]bY'di \g]YfYbXY_i \]b'I\b' \[\] \[\] \[\] \[\] \[\] \[\] \[\] \[\] \[\] \] \[

Y`Y[UbhYb`FYghUifUbhg`fY]W\h"`5i »YfXYa ``UXYb`ibnÀ\`][Y`DUf_g ibX`[fØbY`CUgYb`XUni `Y]bž`X]Y`GYY`Y`VUiaY`b`ni ``UggYb`ibX`X]YBUhif`ni `[Yb]Y»Yb"

±b`X]YgYa '6`c[Ufh]_Y``bY\a Yb`k]f`X]W\`a]h`Ui ZY]bY
9bhXYW_i b[ghci f`Xi fW\`DUb_ck "`K]f`nY][Yb`X]f`X]Y`\]ghcf]gW\Yb
<][\`][\hgž`X]Y`_Ògh`]W\Yb`?i`]bUf]_Ub[YVchYž`X]Y``YVYbX][Y
?i bgh! i bX`?i`hi fgnYbY`i bX`j]Y`Yg`a Y\f"A UW\`X]W\`VYfY]hž
DUb_ck j cb`gY]bYf`VYghYb`GY]hY`_YbbYbni`YfbYb`i bX`j]Y``Y]W\h
gc[Uf`XY]bY`bYi Y`@]YV`]b[gghUXh`]b`6Yf`]b`ni `YbhXYW_Yb`

$DUb_ck `YbhXYW_Yb'9]b', VYfV`]W_'ØVYf'X]Y \\ j]Y`ZÀ`h][Yb'GhUXhhY]`Y$

DUb_ck ']gh'Y]bYf'XYf'j]Y`ZÀ`h][ghYb'i bX'XmbUa]gW\ghYb'6Yn]f_Y 6Yf`]bg"'Jcb'W\Ufa UbhYb'5`hVUi j]YfhY`b'V]g'\]b'ni 'a cXYfbYb K c\b[Y[YbXYb'V]YhYh'DUb_ck 'Y]bY'VfY]hY'DU`YhhY'Ub'GhUXhhY]`Ybž X]Y'Yg'k Yfh'g]bXž'YbhXYW_h'ni 'k YfXYb"'\XXYf'GhUXhhY]`'\Uh'gY]bYb Y][YbYb'7\UfU_hYf'i bX'7\Ufa Yž'XYf'X]Y'6Ygi W\Yf']b'gY]bYb'6Ubb n]Y\h"

9]b VYgcbXYfg fY]nj c``Yf GhUXhhY]``]gh DfYbn`Ui Yf 6Yf[žVY_Ubbh ZØf gY]bY bcghU`[]gWXY5ha cgd\AfY i bX X]Y nU\`fY]WXYb 7 UZÅgž 6ci h]ei Yb i bX ?i bgh[U`Yf]Yb"'<]Yf Z]bXYb G]Y X]Y VYfØ\a hY ?c``k]hnd `Uhnž X]Y j cb \]ghcf]gWXYb; YVAi XYb i a [YVYb]gh i bX cZh Y]b 'HfYZZdi b_h ZØf X]Y ``c_U`Y 7 ca a i b]hm XUfghY``h" 8]Y GhfU» Yb g]bX [YgÀi a h j cb [i h Yf\U`hYbYb 5`hVUi hYbž k À\fYbX XYf [Ya Øh`]WXYA Ui YfdUf_ a]h gY]bYa 'gcbbhÀ[`]WXYb': `c\a Uf_h Y]b VY`]YVhYf C fh ZØf 6Yk c\bYf i bX 'Hci f]ghYb']gh"

B]W\hik Y]hiYbhZYfbhi`]Y[hiK Y]\rightarrow YbgYYziY]biGhUXhhY]`ziXYfiZ\text{2}f gY]bYbik i bXYfgW\ObYbiK Y]\rightarrow YbgYYia]hij]Y\iii; f\text{0}biVY_Ubbhi]gh" 8YfiGYYiV]YhYhib]W\hibi fiFUi a iZ\text{0}fi9f\c\ii b[iXi fW\iGW\k]a a Yb i bXi6cchgZU\fhYbzigcbXYfbiUi W\iY]bYiJ]Y\inU\iij cbi5_h]j]h\hip\text{0}hYb k]YiGhfUbXV\hixYfi bXiGdUn]Yf[\hib[YiUa il ZYf":8]Yil a [YVi b[ik]fX gck c\iij cbi: Ua]\i]YbiU\giUi W\ij cbiGdcfhVY[Y]ghYfhYbi[YgW\hinhz X]Yi[YfbiX]YiBUhi fi[Yb]Y\rightarrow Yb

DUb_ck 'gY`Vgh`\Uh'U`g`NYbhfi a 'XYg`[`Y]W\bUa][Yb`6Yn]f_g'j]Y`ni 'V]YhYb"'8]Y`gW\ÒbY`6i bXYgghfU» Yž`X]Y`Xi fW\`XYb`GhUXhhY]`ZØ\fhž`]gh`[Ygd]W_h`a]h`; YgW\ÀZhYbž`FYghUi fUbhgʻi bX`_i`hi fY``Yb9]bf]W\hi b[Yb"'<]Yf`VYZ]bXYh`g]W\`Ui W\`XUg`DUb_ck Yf?i`hi f\Ui gž`XUg`Y]bY`J]Y`nU\``j cb`JYfUbghU`hi b[Yb`i bX?cbnYfhYb`V]YhYhž`X]Y`I f`Ui VYf`i bX`9]b\Y]a]gW\Y`[`Y]W\Yfa U» YbUbn]Y\Yb"

9]b'k Y]hYfYf']bhYfYggUbhYf'GhUXhhY]`']gh'6`Ub_YbVi f[ž'Y]b
fi \][YfYf'HY]`'j cb'DUb_ck ž'XYf'j cf'U``Ya 'Xi fW\'gY]bY'[fØbYb
K c\bj]YfhY`'i bX'X]Y'BÀ\Y'ni a 'GW\Òb\Ui gYf'5``YY'VYgh]W\h''
8]Y'W\Ufa UbhY'5ha cgd\AfYž'[YdUUfh'a]h'a cXYfbYb
K c\bUb`U[Yb'i bX'Ui gfY]W\YbX'; fØbZAW\Ybž'a UW\h'6`Ub_YbVi f[
ni 'Y]bYa ']XYU`Yb'Cfh'ZØf': Ua]`]Yb'i bX'Fi \Yqi W\YbXY''

: Øf B Uhi f`]YV\UVYf]gh? Ufck 'Y]b k U\fYg DUfUX]Yg" A]h Y]b Ya
XYf [fÒ» hYb ni gUa a Yb\Ab[YbXYb B Uhi f[YV]YhY 6Yf`]bgž XYa
? Ufck Yf 'HY]WX ž V]YhYh X]YgYf 'GhUXhhY]` 'Y]bY 'J]Y`nU\` 'j cb
K UbXYf! i bX F UXk Y[Yb" <]Yf _Ubb a Ub X]Y 'j]Y ZÂ`h][Y : `cfU i bX
: Ui bU 6Yf`]bg Yf YVYb i bX X]Y F i \Y XYf B Uhi f [Yb]Y» Yb"</pre>

I a 'Y]bYb'VYggYfYb', VYfV`]W_'ØVYf'X]Y'GhUXhhY]`Y'DUb_ck g'ni VY_ca a Ybž'\]Yf'Y]bY'_`Y]bY', VYfg]W\hghUVY``Y.

| GhUXhhY]` | 6YgcbXYf\Y]hYb | $5_h]j]hAhYb$ |
|------------------|-----------------------------------|----------------------------------|
| DfYbn`Ui Yf'6Yf[| <]ghc f]gW\ Y | : `c\a Uf_h [·]]a |
| | 5`hVUi hYbž'7UZÅg | A Ui YfdUf_ |
| K Y]» YbgYY | ⇒Xm``]gW\Yf'GYYž'j]Y` | GWk]a a Ybž6cch |
| | ; fØb | ZU\fYb |
| DUb_ck | ?i`hifY``Y | ?cbnYfhVYgi WXY |
| | JYfUbghU`hib[Yb | |
| 6`Ub_YbVif[| Fi\][Y'K c\b[Y[YbX | DUf_g'i bX'9f\c`i b[|
| ? Ufck | ; fc»Y [·] BUhi f[YV]YhY | K UbXYfbž [*] FUXZU\fYb |

XYYf'GhUXhhY]``]b'DUb_ck'\Uh'Yhk Ug'9]bn][Ufh][Yg'ni 'V]YhYbž'k Ug X]Y'9f_i bXi b['XYf'FY[]cb'gc'gdUbbYbX'a UW\h''CV'G]Y'Ui Z'XYf Gi W\Y'bUW\'_i `hi fY``Ya '9f`YVYbž'BUhi f`cXYf'Y]bZUW\'bi f'bUW\ Y]bYa '[Ya Øh`]W\Yb'7UZ\^g]bXž'DUb_ck'\Uh'Z\Øf'YXYb'; YgW\a UW_ Yhk Ugʻni `V]YhYb"'9g`]gh`Y]b`Cfhž`Ub`XYa `; YgW\]W\hY`Ui Zʻa cXYfbY @YVYbgUfh`hf]ZZh`i bX`XYf`gck c\``9]bk c\bYf`U`g`Ui W\`6Ygi W\Yf VY[Y]ghYfh"

<]ghcf]gW\Y'<][\`][\hg']b'DUb_ck 9bhXYW_i b[ghcif'XifW\'X]Y'JYf[Ub[Yb\Y]h</pre>

DUb_ck žY]b GhUXhhY]``]a '6Yf`]bYf'BcfXcghYbž']gh'b]W\h'bi f VY_Ubbh'ZØf'gY]bY '`YVYbX][Y'?i `hi f'i bX'W\Ufa UbhYb'7UZÅgž gcbXYfb'Ui W\'ZØf'gY]bY'VYY]bXfi W_YbXY'; YgW\]W\hY"'A]h'gY]bYb nU\`fY]W\Yb'\]ghcf]gW\Yb'; YVÀi XYb'i bX'8Yb_a À`Yfb'V]YhYh X]YgYf'GhUXhhY]``Y]bY'k i bXYfVUfY'; Y`Y[Yb\Y]hž']b'X]Y JYf[Ub[Yb\Y]h'XYf'XYi hqW\Yb'<Ui dhqhUXh'Y]bni hUi W\Yb"

9]bY'XYf'\YfUi gfU[YbXghYb'GY\Ybgk ØfX][_Y]hYb']b'DUb_ck']gh
XUg'GWX'cgg'GWX Òb\Ui gYb"'I fgdfØb[`]WX']a '%+"'\\J\f\i bXYfh
YfVUi h\(\f{z}\)X]YbhY'XUg'GWX'cgg'U'g'Gca a YffYg]XYbn'Z\(\f{z}\)Y
dfYi \(\gamma\)]gWXYb'? \(\f{z}\)b][Y"'<Yi hY'VY\YfVYf[h'Yg'Y]b'AigYi a \(\f{z}\)XUg'X]Y
\(\f{z}\)YgWX]WXhY'XYf'dfYi \(\gamma\)]gWXYb'A cbUfWX]Y'i bX'X]Y'9bhk]\(\waller{y}\)i b[
6Yf']bg'h\Ya Uh]g]Yfh"'6Ygi WXYf'_\ObbYb'X]Y'dfi b_j c``Yb'F\(\hat{A}\)i a Y
VYg]WX\h][Yb'i bX'a Y\f'\ØVYf'X]Y'\ZUgn]b]YfYbXY'; YgWX]WX\hY
Yf\(\f{z}\)\\fYb\(\f{z}\)X]Y'\g]WX'\]bhYf'XYb'K \(\hat{A}\)bXYb'j YfV]f[\h"

9]b'k Y]hYfYg'k]WXh][Yg'\]ghcf]gWXYg'9`Ya Ybh']gh'X]Y'

K]`\Y`a gfi \z'Y]bY'XYf'À`hYghYb'J]``Yb'j cb'DUb_ck z'X]Y']a

ZfØ\Yb'%- "'*J\f\i bXYfh'Yff]WXhYh'k i fXY"'8]Y'5fWX]hY_hi f']gh'Y]b

k i bXYfVUfYg'6Y]gd]Y``ZØf'XYb'Gh]``XYf'XUa U`][Yb'NY]h'i bX'V]YhYh

ni XYa 'Y]bYb'9]bV`]W_']b'X]Y'gcn]U`Y'; YgWX]WXhY'XYg'GhUXhhY]`g"

8]Y'I a [YVi b['`ÀXh'ni 'Y]bYa 'YbhgdUbbhYb'GdUn]Yf[Ub[']ba]hhYb

j cb'VYY]bXfi W_YbXYb'6Ui hYb'Y]b"

DUb_ck ']gh'Ui W\ '< Y]a Uh'j cb'Gh"' \approx gYd\g'?]fW\ Yž'Y]bY bYc[ch]gW\ Y'?]fW\ Yž'X]Y'%-\$%'Y]b[Yk Y]\h'k i fXY"'8]Y'_i bghj c``Y 5i gghUhhi b['i bX'X]Y'VYY]bXfi W_YbXYb'; `UgZYbghYf'a UW\Yb'X]YgY?]fW\ Y'ni 'Y]bYa 'k U\fYb'\\delta k Y`"'G]Y'Yfn\\\h'b]W\ h'bi f'j cb'XYf ; `Ui VYbg[YgW\]W\ hY'XYf'6Yk c\bYf\Z'gcbXYfb'gd]Y[Y`h'Ui W\ 'X]Y UfW\]hY_hcb]gW\ Yb'HfYbXg'X]YgYf'9dcW\ Y'k]XYf"

 $9]b`kY]hYfYg`\]ghcf]gWkYg`<\][\ \][\ \h']gh'XYf'DUb_ckYf'GhfY`]hnYf\\ D`Uhnž'XYf']a`&\\f'%, *, `Ub[Y`Y[h'kifXY'''<]Yf'Z]bXYb`g]Wk\\ nU\ `fY]WkY'8Yb_a A`Yfž'X]Y`k]Wkh][Y`\]ghcf]gWkY':][ifYb`XYf\\ FY[]cb`k ØfX][Yb'''6YgcbXYfg`VYaYf_YbgkYfh']gh'XUg'8Yb_a U``ZØfX]Y'2CdZYf'XYg': UgWk]gaig$

8 Y hU] `c

 $6 \ Ygi \ WX \ Yb \ G]Y \ i \ bg \ Ui \ Z. \ Y]b \ Y!f Y]g Y "X \ Y$