# **PTRL4024**

8f]``]b[ ': `i ]Xg'UbX'7Ya Ybh]b[

HYfa "H\fYY" ## "&\$&\$

# 7ci fgY<sup>-</sup>Cj Yfj ]Yk

## GHJZ7cbHJWh8YHJ]`g

### 7cbj Ybcfg

B Ua Y	9a U]`	5j U]`UV]`]hm	@cWUhjcb	D\cbY
N\]I ] <sup>.</sup> 7 \Yb	n\]I]W4 i bgk "YXi "Ui	, 0	-	Ž*%'&'-',)
			@Yj Y``&"`H9H6	) % &

## GWXcc``7cbHJWhʻ±bZcfa Uh]cb

GW.cc``cZA ]bYfU`g`UbX`9bYf[ mF Ygci fWYg C`X`A U]b`6i ]`X]b[ ž`@Yj Y``%z\*%) - "fP %) Ł I BGK "GM8B9MBGK "&\$) &\*51 GHF5@-5

H. 'Ž \* %'f&Ł'-',)')\$\$\*

9. a YfY"hYUW.]b[4 i bgk "YXi "Ui

 $K \cdot \underline{k} \, \underline{k} \, \underline{k} \, \underline{"Yb[\ ]bYYf]b[\ "i\ bgk\ "YXi\ "Ui\ \#a\ ]bYfU\underline{"g!YbYf[\ mfYgci\ fWYg]} }$ 

# 7ci fgY 8YHJ] g

## 7 fYX]hDc]bhg\*\*

### Gi a a UfmcZh\Y 7ci fgY

H\Y`Wci fgY`Wcj Yfg`Vch\ h\Y`h\YcfmUbX`dfUWj\W\`Udd`]\Wbjcbg`cZXf]``]b[ 'Zi ]Xg`UbX`k Y```Wa Ybhjb[ hYW.bc`c[ m''H\Y`a U]b`hcd]\Wg`]bWi XY. h\Y`Z bWfjcbgž\Wca dcg]hjcb`UbX`UXX]hj Yg`cZXf]``]b[ 'Zi ]Xg\WUmUbX dc`ma Yf`VX.Ya ]ghfmUbX`Udd`]\Wbjcbg`]b`Xf]``]b[ 'Zi ]Xg\Xf]``]b[ 'Zi ]X`XYbg]lmXYhYfa ]bUhjcb`UbX`WJ`W``Uhjcbg/Xf]``]b[ 'Zi ]X`Zj`hfUhjcb`UbX`a i X`\W\_]b[ 'dfc\W`gg\5D=Xf]``]b[ 'Zi ]X`dfcdYfhjYgžYei ]da YbhUbX`hYghjb[ dfc\W`Xi fYg\W.Ya ]\WJ``UbU`mg]g\Xf]``]b[ 'Zi ]X`gmghYa `XYg][ b`Zcf`\Wcbhfc``Zcfa Uhjcb`XUa U[ Y`UbX`k Y``VcfY ghUY]`]hm'Xf]``]b[ 'Zi ]X`\mXfUi `]\Wg`UbX`W hhjb[ g`hfUbgdcfhUhjcb\W\a Ybha Ubi ZU\Wi fYž\Wca dcg]hjcb`UbX ghUbXUfX]nUhjcb\Wa Ybhg`i ffmf\Yc`c[ mdfcdYfhjYg\5D=\Wa Ybhjb[ 'Yei ]da Ybh UbX`dfc\WXi fYg\Wa Ybhg`i ffmXYg][ b`UbX`\WJ`W``Uhjcbg\a i X`fYa cj U``Vm\Wa Ybh'[ Ug`a ][ fUhjcb\\Wa Ybhjb[ 'Yei ]da YbhUbX`dfc\WXi fYg\dcgh'cV`\\cbg\ZyfUhjcbg`UbX`Yj U`i Uhjcb\Xf]``]b[ 'Zi ]Xg`UbX\\Wa Ybhjb[ 'Yei ]da YbhUbX`dfc\WXi fYg\dcgh'cV`\\cbg\ZyfUhjcbg`UbX`Yj U`i Uhjcb\Xf]``]b[ 'Zi ]Xg`UbX\\Wa Ybhjb[ 'YucfUhcfm'

## 7 ci fgY 5]a g

H\]g`Wci fgY`k ]```YbUV`Y`ghi XYbhg`rc`UWei ]fY`Z bXUa YbhU``\_bck `YX[Y`cZXf]``]b[ 'Zi ]Xgž'Xf]``]b[ '\mXfUi `]Wg UbX`WYa YbhJb[ 'hYW\b]ei Y`UbX`rc`Udd`mih\Y`h\Ycfmhc`h\Y`XYg][ bž'Yj U`i UhJcb`UbX`cdhJa ]nUhJcb`cZXf]``]b[ Zi ]X`dfc[ fUa ž'Xf]``]b[ `\mXfUi `]Wg`UbX`WYa YbhJb[ 'cdYfUhJcbg"

#### 7 ci fgY @YUfb]b[ Ci hWca Yg

- %" 8 Yg][ b`UbX`Yj U`i UhY`Xf]``]b[ `Zi ]X`dfc[ fUa `UbX`WYa Ybh]b[ `cdYfUh]cbg`i bXYf`gdYW]Z]Wk Y`` WcbX]h]cbg
- &" DfYdUfY UbX hYghXf]``]b[ 'Zi ]Xg UbX WYa Ybh]b[ 'g`i ffmUVWcfX]b[ 'hc '5 D=ghUbXUfXg
- "Cdha]nY:Xf]``]b[:Zi]X'\mXfUi`]Wa;Zcf'\][\fUhY:cZdYbYhfUh]cb:UbX:Wih]b[g:hfUbgdcfhUh]cb:YZ]W]YbWh

### HYUWX]b[ 'GhfUhY[]Yg'

%"K YY\_`m``YWi fYg`UfY`XYg][bYX`hc`dfcj]XY`ghi XYbhg`Z bXUa YbhU``i bXYfghUbX]b[`h\fci[\`U`gYf]Yg`cZhcd]W cb`Xf]``]b[`Zi]Xgž`Xf]``]b[`\mXfUi`]Wg`UbX`WYa Ybh]b["

&"'H\Y'Z bXUa YbHJ``a UhYf]U``Wcj YfYX`]b`h\Y``YWi fYg`]g`gi ddcfhYX`VmdfcV`Ya !gc`j ]b[ 'Yl YfW]gYg`]b hi hcf]U`g`UbX`WUgg`X]gW gg]cbg"

'"'@YUfb]b['Xif]b['`YWnifYg']g'Zifn\Yf'giddcfnYX'Vm[fcid'VUgYX``UVcfUhcfmdfUWnJWYg"("'Cb`]bY``YUfb]b['giddcfn]g'U`gc'UjU]`UV`Y'n\fci[\'AccX`Y"

## 5XX]h]cbU`7ci fgY ±bZcfa Uh]cb

DfYfYei ]g]hY. DHF@\$%)

## 5ggYgga Ybh

## 5ggYgga Ybh HUg\_g

5ggYgga Ybh'hJg_	K Y][\h	8iY'8UHY	Gh XYbh@YUfb]b[ Ci hWca Ygʻ5ggYggYX
5gg][ ba Ybh'% '7`Um#dc`ma Yf W.Ya ]ghfmi	) ।	K YY'	%ž &
5gg][ ba Ybh&'	) ၊	K YY_')	%ž <sup>*</sup> &
A ]XhYfa '91 Ua '	%) ၊	K YY_'+	%ž <sup>*</sup> &
5gg][ ba Ybh' ·	) ၊	K YY_'-	•
5gg][ ba Ybh( ·	)	K YY_"%\$	%ž <sup>*</sup> &
@UVcfUltcfmi	%\$ı	K]h\]b'hkc'kYY_g'UZhYf'h\Y 'UV"	%ž'&ž''
Hi kcf]U`DUfk]WjdUk]cb'	)	K YY_`m	%ž`&ž`'
: ]bU``91 Ua `	) \$1	K ]h\]b YI Ua 'dYf]cX	%ž`&ž`'

### 5ggYgga Ybh'8YHJ]`g

5ggYgga Ybh'% 5gg][ ba Ybh'% '7`Um#dc`ma Yf'W\Ya ]ghfm

8YHJ]`g.7`Um#dc`maYf'W\Ya]ghfm

Gi Va ]gg]cb bchYg.Cb`]bY A ccX`Y Gi Va ]gg]cb

Hi fb]hjb gYhjb[. H\]g ]g bchU Hi fb]hjb Ugg][ ba Ybh

5ggYgga Ybh& 5gg][ ba Ybh&

8YHJ]`g. A i X'k Y][\hWU`W `Uh]cbg`UbX'5D=dfcdYfh]Yg

5ggYgga Ybh' . A ]XhYfa '91 Ua

GhUfhXUhY. K YY\_+

**8 YHJ]`g**. A ]XhYfa `Yl Ua `Wcj Yfg`k YY\_'%hc`k YY\_') ``YWh fY`WcbhYbhg"`cbY`\ci f`A ccX`Y`cb`]bY`E i ]n"; i ]XY`]bYg`Zcf`\Y`d]b[ 'h\Y`dfYdUfUh]cb`Zcf`h\Y`a ]XhYfa `Yl Ua `k ]``VY`fY`YUgYX`df]cf`hc`h\Y`Yl Ua "

Gi Va ]gg]cb bchYg.Cb ]bY A ccX Y E i ]n

Hi fb]hjb gYhjb[. H\]g ]g bchU Hi fb]hjb Ugg][ ba Ybh

5ggYgga Ybh'(. 5gg][ ba Ybh'

8YHJ]`g.

Gi Va ]gg]cb bchYg.Cb`]bY A ccX`Y Gi Va ]gg]cb

Hi fb]h]b gYh]b[. H\]g ]g bchU Hi fb]h]b Ugg][ ba Ybh

5ggYgga Ybh). 5gg][ba Ybh(

8YHJ]`g.7YaYbh]b['WU`W`Uh]cbg

Gi Va ]gg]cb bchYg.Cb`]bY A ccX`Y Gi Va ]gg]cb

 $\label{eq:higher_problem} \mbox{Hi fb]h]b$^{-}gYh]b[.^{-}H\]g$^{-}g$^{-}bchU$^{-}Hi fb]h]b$^{-}Ugg][$ba$^{-}Ybh$^{-}h]b$^{-}Ugg][$ba$^{-}h]b$^{-}Ugg][$ba$^{-}h]b$^{-}Hi fb]h]b$^{-}h]h$^{-}$ 

5ggYgga Ybh'\*. @UVcfUhcfm

8YHJ]`g.

&\$`BcjYaVYf	

## FYgci fWyg

#### DfYgWf]VYX F Ygci fWyg

Gi ddcfha UhYf]U`Zcf`h\]g`Wci fgY`]bWi X]b[ žk\YbYj Yf`Uj U]`UV`YžWcd]Yg`cZ`YWi fY`bchYgž`YWi fY`g`]XYgž fYWca a YbXYX`fYUX]b[ gžYhWi`WUb`VY`Zci bX`cb`A ccX`Y" H\Y``YWi fY`bchYg#g`]XYg`a UmVY`j ]Yk YX`UbX`Xck b`cUXYX`Zfca 'h\Y`I BGK !A ccX`Y.\hd.##a ccX`Y"hY`h'i bgk "YXi "Ui #

#### FYWca a YbXYX FYgci fWyg

: c``ck]b[g'UfY'h\Y'fYWca a YbXYX'Vcc\_g'Zcf'h\]g'Wci fgY.

- F mYb 7 UYbbž < 7 < '8 Uf Ymž; Ycf[ Y F "; fUm 7 ca dcg]h]cb 'UbX 'DfcdYfh]Yg 'cZ8 f]``]b[ 'UbX 7 ca d`Yh]cb : 'i ]Xgž +h\ 'YX]h]cbž; i 'ZDfcZYgg]cbU``Di V`]g\]b[ ž'9 `gYj ]Yfž &\$%\* "
- 6ci f[ cmbY :5"H"'>f"žA ]``\Y]a :? "? "ž7 \YbYj YfnA "9"'UbX'Mci b[ :: "G"'>f". :5dd`]YX'8 f]``]b[ 9b[ ]bYYf]b[ žGD9'HYI Mcc\_'GYf]YgžJ c`" &žF ]WUfXgcbžHL žI G5ž% %"
- BY`gcbž'9"6"'UbX'; i ]``ch'8". 'K Y```7 Ya Ybh]b[ 'fGYWcbX'9X]h]cblž'GW\`i a VYf[ Yfž'&\$\$\*"

#### 7ci fgY '9j U`i Uh]cb 'UbX '8Yj Y`cda Ybh

5 hih\Y'YbX'cZYUW\'Wci fgYž'U```ghi XYbhg`k]```\Uj Y'h\Y'cddcfhi b]hmhc Wca d`YhY'U'Wci fgY'Yj U`i Uh]cb'Zcfa "H\YgY'Ubcbma ci g'gi fj Ymg'\Y'd'i g'i bXYfghUbX'mci f'j]Yk g'cZh\Y'Wci fgYžmci f'`YWhi fYfg'UbX'h\Y'Wci fgY a UhYf]U`g"'K Y'UfY'Wcbh]bi ci g`m`]a dfcj ]b['ci f'Wci fgYg'VUgYX'cb'ghi XYbhZYYXVUW\_ž'UbX'mci f'dYfgdYWf]j Y ]g'j U`i UV`Y"

: YYXVUW\_`]g`[]j Yb`j ]U`<u>\hdg.#ghi XYbh'i bgk "YXi "Ui #a mYl dYf]YbW</u>`UbX`mci `k ]```VY`bch]Z]YX`k \Yb`h\]g`]g Uj U]`UV`Y`Zcf`mci `hc`Wca d`YhY"

K Y'U'gc'YbWci fU[Y'U'`'gh XYbhg'hc'g\UfY'Ubm'ZYXVUW\_'h\Ym\Uj Y'Ubm'h]a Y'Xi f]b['h\Y'Wci fgY'—']Zmci\Uj Y'U'WcbWfbž'd'YUgY'WcbhUWhi g']a a YX]UhY'm'

## Gi Va ]gg]cb cZ5ggYgga YbhHUg\_g

H\Y'GWkcc``\Ug'XYj Y`cdYX'U'[i]XY`]bY'hc'\Y`d'mci'k\Yb'gi Va]hh]b['U'Wci fgY'Ugg][ba Ybh'

K Y YbWci fU[Y'mci'hc'fYhJ]b'U'WcdmcZYj YfmUgg][ba Ybhgi Va]hYX'Zcf'UggYgga YbhZcf'mci f'ck b'fYWcfX Y]hYf']b'YUfXWcdmcf'Y'YWfcb]WZcfa "

5 "UggYgga Ybhg a i gh\Uj Y Ub UggYgga YbhWcj Yf g\YYhUHUWXYX"

#### @UhY Gi Va [gg]cb cZUb 5gg][ ba Ybh

: i ```a Uf\_g`Zcf`Ub`Ugg][ ba Ybh'UfY`cb`mdcgg]V`Y`k \Yb`Ub`Ugg][ ba Ybh]g`fYVW]j YX`Vmh\Y`Xi Y`XUhY"`

K Y'i bXYfgHJbX'h\UhiUhih]a Yg'mci 'a Umbch'VY'UV'Y'hc'gi Va ]hiUb'Ugg][ ba Ybh'cb'h]a Yž'UbX'h\Y'GW\cc``k ]``UWWca a cXUhY'UbmZJ]f'UbX'fYUgcbUV'Y'YI hYbg]cb"'K Y'k ci `X'fYWca a YbX'mci 'fYj ]Yk 'h\Y'I BGK 'GdYWJU` 7 cbg]XYfUh]cb'[i]XY`]bYg'—'gYY'gYWfJcb'VY'ck "

@UhY`gi Va ]gg]cb`k ]``bchVY`UVWYdhYX`UbX`k ]``VY`Wcbg]XYfYX`Ug`bc`gi Va ]gg]cb"

# GdYWJU`7cbg]XYfUhJcb

Mci 'Wub'Udd`mZcf'gdYWJU`'Wcbg]XYfUhJcb'h\fci [\'<u>H\Y'Bi WYi g'Gh XYbh<i V</u>'k\Yb']``bYgg'cf'ch\Yf WJfW a ghUbWfg']bhYfZYfY'k]h\'mci f'UggYgga YbhdYfZcfa UbWf'''G]W\_bYggža ]gUXj Ybh fY'cf'ch\Yf WJfW a ghUbWfg'VYmcbX'mci f'Wcbhfc``a Um

- DfYj Ybhmci Zfca 'Wca d'Yhlb[ 'U'Wci fqY fYei ]fYa Ybh
- ? YYd 'mci 'Zfca 'UthYbX]b[ 'Ub'UggYggUV'Y'UWhj ]hm
- Ghodimoi igi Va ]hhlb[ 'UggYggUV'Y'k cf 'Zcf'U'Wci fgY

K YʻUg\_ʻh\Uhmci 'd`YUgY WcbhUWh\Yʻ7 ci fgYʻ7 cbj Ybcfʻ]a a YX]UhY`mcbWYʻmci '\Uj Y`Wca d`YhYX'h\YʻgdYW]U` Wcbg]XYfUh]cbʻUdd`]WUh]cbžbc``UhYf'h\UbʻcbY`k YY\_`Zfca 'gi Va ]gg]cb"

A cfY XYHJ]  $\dot{g}$  cb  $\dot{g}$  dYWJU  $\dot{w}$  bg]XYfUh]cb  $\dot{w}$  bb  $\dot{v}$  Y  $\dot{z}$  ci bX  $\dot{u}$  b  $\dot{k}$  k k  $\dot{g}$  h  $\dot{x}$  Y bh'i bgk  $\ddot{y}$  Xi  $\ddot{u}$  i  $\ddot{y}$  dYWJU  $\dot{w}$  bg]XYfUh]cb

#### Gh XYbhGi ddcfh

H\Y`I b]j Yfg]lmUbX`lh\Y`: UW`lmdfcj ]XY`U`k ]XY`fUb[Y`cZgi ddcfhgYfj ]Wyg`Zcf`gh XYblgž]bWi X]b[.

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

Mci f`YWi fYf'UbX'h\Y'I b]j Yfg]lmk]``YI dYWimci f`gi Va ]lhYX'Ugg][ ba Ybhg'UfY'lfi `mmci f`ck b'k cf\_"'I BGK \Ug'j YfmWYUf'[i]XY`]bYg'cb'k \Uhd`U[]Uf]ga ']g'UbX'\ck 'hc'Uj c]X']h'D`U[]Uf]ga ']g'i g]b[ 'h\Y'k cfXg'cf ]XYUg'cZch\Yfg'UbX'dfYgYbh]b[ 'h\Ya 'Ug'mci f`ck b"'D`U[]Uf]ga ']g'U'mdY'cZ]bhY``YWi U`'h\YZh''±i\Wb'hU\_Y a UbmZcfa gžZfca 'XY`]VYfUhY'W\YUh]b[ 'hc'UW]XYbhU``mWcdm]b[ 'Zfca 'U'gci fW'k]h\ci hUW\_bck `YX[ Ya Ybh' H\Y'I b]j Yfg]lm\Ug'UXcdhYX'Ub'YXi WUh]j Y'UddfcUW\ 'hc'd`U[]Uf]ga 'UbX'\Ug'XYj Y`cdYX'U'fUb[ Y'cZ fYgci fW'g'hc'gi ddcfhghi XYbhg"'5``h\Y'XYhU]`g'cb'd`U[]Uf]ga ž]bWi X]b[ 'gca Y'i gYZ ``fYgci fW'gžWUb'VY Zci bX'Uhk k k "qhi XYbhi bak "YXi "Ui #d`U[]Uf]ga "

 $5 ```A ]b]b[ "9b[ ]bYYf]b[ "ghi XYbhg"UfY"fYei ]fYX"hc "Wca d`YhY"U"ghi XYbhXYWUfUh]cb" Zcf"UWUXYa ]W]bhY[ f]hm k \]W. ]g"ci h]bYX']b"h\Y"Ugg][ ba YbhWcj Yf"g\YYhg""6mg][ b]b[ "h\]g"XYWUfUh]cbž"mci "U[ fYY"h\Uh'mci f"k cf_"]g mci f"ck b"cf][ ]bU"k cf_"$ 

⊋mci 'bYYX'gca Y'UXX]h]cbU``gi ddcfhk]h\ 'mci f`k f]h]b[ 'g\_]``gž'd`YUgY'WcbhUWh\Y'@YUfb]b[ '7 YbhfY'cf'j]Yk gca Y'cZh\Y'fYgci fWg'cb'h\Y]f`k YVg]hY. 'k k k "`Wi bgk "YXi "Ui "'H\Y'@YUfb]b[ '7 YbhfY']g'XYg][ bYX'hc'\Y`d mci ']a dfcj Y'mci f'UWUXYa]Wk f]h]b[ 'UbX'Wca a i b]WUh]cb'g\_]``g"'Gca Y'ghi XYbhg'i gY'h\Y'7 YbhfY'gYfj]W/g VYWUi gY'h\YmUfY'Z]bX]b[ 'h\Y]f'Ugg][ ba Ybhg'U'W\U``Yb[ Yžch\Yfg'VYWUi gY'h\Ymk Ubhhc']a dfcj Y'Ub'U`fYUXm gi WW/ggZ ``UWUXYa]WdYfZcfa UbW/"

# 5 WUXYa ]W + DZcfa Uh]cb

# 7 ci fgY F Ygi `hg

: cf<sup>'</sup>XYfU]<sup>'</sup>g<sup>'</sup>cb<sup>'</sup>I BGK <sup>'</sup>UggYgga Ybh'dc<sup>'</sup>]Whž'd<sup>'</sup>YUgY<sup>'</sup>j ]g]h '<u>k k k "gh XYbh'i bgk "YXi "Ui #UggYgga Ybh</u>

 $\pm gca\ Y']bgHUbW'g'mci\ f'Z]bU``Wci\ fgY'fYgi\ `hia\ Um'VY'k\ ]h\ Y`X'UbX'bch'fY'YUgYX'cb'h\Y'I\ BGK 'd`UbbYX'XUHY'' H\ ]g']g']bX]WUHYX'VmU'Wci\ fgY'[\ fUXY'fYgi\ `hicZY]h\ Yf.$ 

• @9 '-']bX]\WUhYg'mci '\Uj Y'bch\Wca d'YhYX'cbY'cf'a cfY']hYa g'cZUggYgga Ybh/cf

- VfcUXVUbX'WcbbYWfjcb'f&) \* '\_V]h#gYWcf'ZUghYfŁ
- UV]]mhc'j ]Yk 'ghfYUa ]b['j ]XYc'f\][\'cf'`ck 'XYZ]b]h]cb'l BGK 'HJ 'cdh]cbgŁ

A cfY ]bZcfa Uh]cb UVci hgmghYa 'fYei ]fYa Ybhg ]g Uj U] UV Y UhKkk mgh XYbh'i bgk "YXi "Ui #a ccX Y! gmghYa!fYei ]fYa Ybhg

.

## 5 WWYgg]b[ '7ci fgY'A UhYf]U`g'H\fci [\'AccX`Y

7 ci fgY'ci h]bYgžgi ddcfna UhYf]U`g`UfY'i d`cUXYX`hc`A ccX`Yž'h\Y'i b]j Yfg]lmighUbXUfX`@YUfb]b[ A UbU[ Ya Ybh'GmghYa 'f@A GŁ"'+b`UXX]r]cbžcb!`]bY`Ugg][ ba Ybh'gi Va ]gg]cbg`UfY`a UXY'i g]b[ 'h\Y Ugg][ ba Ybh'XfcdVcl 'ZUVJ']lmdfcj ]XYX`]b'A ccX`Y"'5```Ybfc``YX'gh XYbhg`UfY`Ui hca Ur]VW\`m]bWl XYX`]b

K_Y`UW_bck_`YX[Y`h\Y`6YXY[U``dYcd`Y`k\c`UfY`h\Y`'fUX]h]cbU``W_ghcX]Ubg`cZh\Y``UbXg`cb`k\]W\`I_BGK ?Ybg]b[hcb`WJa di_g`]g``cWJhYX"