

ARTS3132

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GHJZ:7cbHJWh8YHJ]`g

7cbj Ybcfg

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		Uddc]bha Ybh		

GWkcc~7cbhJWh~abZcfa Uh]cb

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D\cbY. f\$&£'-',) '(,) *

9a U]`. 'gUa 4 i bgk "YXi "Ui

K YVq]hY. k k k "Ufhq"i bak "YXi "Ui #qUa

 $\label{eq:hamiltonian} $$HY'GWKcc``cZhY'5ftg'UbX'AYX]U'kci`X``]_Y'hc'FYgdYWM\cong \cong m5W_bck`YX[Y'h\Y'HfUX]hjcbU``7ighcX]Ubgžh\Y'6YXY[U'`fPYbg]b[hcb'WJadigŁž'; UX][U'`fP]hmUbX'5fh\/'8Yg][b'7UadigYgŁ'UbX'h\Y'B[ibbUkU`dYcd'Y'fbighfU`]Ub'8YZYbW': cf\W'5\WJXYam]b'7UbVYffUŁ'cZh\Y'`UbXg'k\YfY'YUW\'WJadig'cZIBGK']g`c\WJhYX''$

7ci fgY⁻8YHJ]`g

7fYX]hDc]bhg**

Gi a a UfmcZ'h\Y'7ci fgY

 $< \verb|ck|| Xc'Ufh]ghg'hY'''hfi Y'ghcf] Yg'cb'ghU[Y3'K \Uh'UfY'hNY'dfcgdYWhg'UbX'VNU''Yb[Yg'cZa\ U_]b['dYfZcfa\ UbW''] | All the second of the$

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8 YW] g.

 $H\g``UggYgga\Ybh`Ug_g`mci `hc`k\cf_']b`ga\U```[fci\dg`]b`cfXYf`hc`dfYgYbh`U`W'` \$!a]bi hY`Wf]h]WU``UbX#cf WfYUh]j Y`fYgdcbgY`hc`gYhhcd]Wg`cb`a UhYf]U``h\UhYI hYbXg`Wci fgY`WcbhYbh'\`Nci `k]```fYWY]j Y`U'[fci d`a Uf_Zcf`h\Y`dfYgYbhUh]cb`fk cfh\`%) ı `cZWci fgY`UggYgga YbhL`UbX`Ub`]bX]j]Xi U``a Uf_Zcf`mci f`ck b`Wcbhf]Vi h]cb hc`h\Y`dfYgYbhUh]cb`fk cfh\`%) ı `cZWci fgY`UggYgga YbhL$

5XX]h]cbU`XYhU]`g.

: i fh Yf']b Zcfa Uhcb']b Wi X]b[`UggYgga Ybh'Wf]h Yf]U z'gi Va]gg]cb']bgh fi Whcbg'Ub X'fUhcbU'Y'Uf Y'dfcj]XY X'cb A cc X'Y''

Hi fb]hb gYhb[. H\]g]g bchU Hi fb]hb Ugg][ba Ybh

5ggYgga Ybh' . A U'cf F YgYUfW. Dfc YWnfPggUmcf 7fYUhjj Y K cf_Ł

8 YW] g.

: cf'h\Y'A U'cf'FYgYUfW\'DfcYWimci 'a i ghgi Va]hcbY'cZh\Y'Zc``ck]b[.'fl\£'5'gY`Z\XYj]gYX'YggUmf\&z)\\$\$ k cfXg\!''CF.'f\&\:5'd\Umg\#]dhcf'ch\Yf'd]Y\W'cZk f]h|b['Zcf'dYfZcfa Ub\W'f\&z)\\$\$'k cfXg\!''

: YYXVUW_'j]U'@A G

5XX]h]cbU`XYhJ]`g.

: i fh\Yf']bZcfa Uh\cb']bWi X]b['UggYgga Ybh\Wf]hYf]Už'gi Va]gg]cb']bghfi \Wf\cbg'UbX'fUh\cbU'Y'UfY'dfcj]XYX'cb A ccX'Y"

5 hmy b X Ub WY F Yei] f Ya Yb hg

±0 gYa]bUfgžmci k]``UWfj Y`mYb[U[Y'k]h\'WcfY'Wci fgY'WcbhYbh'h\Uhk]``YbUV`Y'mci hc'XYa cbghfUhY UHU]ba YbhcZh\Y'Wci fgY'`YUfb]b['ci hWca Yg.

- $\% = XYbh]ZmUbX`WcbhYI hi U`]gY`U`VfcUX`fUb[Y`cZh\YUhfYg`cZh\Y`fYU``UbX`h\Y]f`X]gh]bWhj Y`Ufh]gh]W qhfUhY[]Yg/$
- &" 7 f]h]WU``miUggYgg'h\Y`Yh\]Wg'cZa U_]b['UbX'k UhW\]b['h\YUhY'h\UhighU[Yg'fYU``cf'hfi Y'Yj Ybhgž j c]WYqž'UbX'dYcd`Y/
- ' " 9| U`i UHY`\ck 'H\YUHY'g`cZH\Y`fYU``fYZYWHUbX`g\UdY`dYfgcbU``UbX`dc`]HJWU``fYU`]HJYg/
- (" 7 cblf]Vi hY`]b`U`h\ci [\hi]``UbX`gcW]U``m`Uk UfY`a UbbYf`hc`ghi XYbh'`YX`[fci d`fYgYUfW\`UbX dfYgYbhUh]cb`k cf_/
-) " 7 cbW/]j Y UbX Yl YW hY U gY ZXYj]gYX fYgYUfW dfc YWith UhW `a]bUhYg]b Ub YggUmcfid]YW cZ WfYUhjj Y k f]h]b["

7 ci fgY GWX YXi `Y

J JYk 'WUqq'Ha YHUV'Y

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K YY_'%" %A Um!"('>i bY	GYa]bUf	FYU`'9h\]Wg.'7cbgYbhž7cbgi`hUh]cbž DUfh]W]dUh]cb	
K YY_'&.'+'>i bY'!'%% GYa]bUf >i bY		FYU``DYcd`Y`UbX`9ZZYWg.`H\Y`K cf_`cZF]a]b] Dfclc_c``	
K YY_'' .'%) '>i bY'!'% >i bY	GYa]bUf	FYU``GY`j Yg. '5i hcV]c[fUd\]WU``H\YUhfY	
K YY_'(.'&%>i bY'!'&) GYa]bUf >i bY		FYU``Jc]WYg.`BUhifU`]ga 'UbX`JYfVUh]a 'H\YUhfY	
K YY_^).^&, ^>i bY^!^&^>i `m	>i `m GYa]bUf FYU` 'Hf]U`g. 'Hf]Vi bU` 'H\YUlfY		
	5ggYgga Ybh	FYgYUfWX`DfcYWhDfcdcgU``XiY	
K YY_'*.') '>i `m'! '- '>i `m	GYa]bUf	: @9L 'K 99?	
K YY_'+.'‰'>i `m'!'%*'>i `m GYa]bUf		FYU`D`UWYg.G]hY!GdYW]Z]WDYfZcfa UbWY	
K_YY_', .'% '>i `m'! '&' '>i `m	GYa]bUf	FYU`FYgYUfW.FYgYUfW.7cbgi`HJh]cbg	
K YY_''&*'>i `m'!'' \$'>i `m	FYU`±bh]a UWJYg. CbY!hc!CbY'DYfZcfa UbWYž 5i hchYUhfcž'UbX'5i X]c'K U`_g		
K YY_'%\$.'&'5i [i gh!'* 5i [i gh	GYa]bUf	FYU``@]Ygž: U_Y`BYk g.`: i hi fY`H\YUhfYg`cZh\Y FYU`	
	5ggYgga Ybh	AUĈFFYgYUFWN DfcYWhXiY:f]XUmž5i[ighi%"	

FYgci fWfg

DfYgWf]VYX F Ygci fWYg

F YUX]b[g'Ug']gh/X']b'h\Y'Wci fgY'gW\YXi `Y'UfY'Uj U]`UV`Y'h\fci [\`A ccX`Y'UbX'j]U``]b_g'hc'h\Y'I BGK `]VfUfm''

FYWca a YbXYX FYgci fWYg

- 5`]gcb': cfgmt\'UbX'7\f]g'AY[gcb'flYXgtz'9WfDW\$\,6aUg_WfSdkFZW\$fdWBSefS`VBdWeWffl@cbXcb.'DU'[fUjY'AUWa]`\Ubz'&\$\$-t
- I `f]_Y'; UfXY'UbX'A Y['A i a ZcfXžFZWSfdWaXDWS^BWab'W, 6 [hWdeW7` Uag` fWde Sf 4 Wdf` e: WTTW` S_ GXWdS` V 4 Wka` V 'f@cbXcb.'6`cca gVi fmž'&\$%*Ł

Gi Va]gg]cb cZ5ggYgga YbhHUg_g Hi fb]h]b Gi Va]gg]cb

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

D`U[]Uf]ga i]gii g]b[ih\Yik cfXgicfi]XYUgicZch\YfgiUbXidfYgYbh]b[ih\Ya iUgimci fick b"i=hWJbihU_Yia Ubm Zcfa gžZfca iXYi]VYfUhYiWXYUh]b[ihciUWW]XYbhU`mWcdm]b[iZfca iUigci fWYik]h\ci hiUW_bck iYX[Ya Ybh'

IBGK [fcidg'd'U[]Uf]ga]bhc'h\Y'Zc``ck]b['WUhY[cf]Yg.

• i bXYfgHJbX'mci f'f][\hg'UbX'fYgdcbg]V]`]h]Yg'Ug'U'gh XYbh'Uhil BGK

5 WUXYa]W + DZcfa Uhjcb

: cf'YggYbhJU`ghi XYbh']bZcfa UhJcb'fY`UhJb['hc.

- fYei Yghg Zcf Yl hYbg]cb/
- `UhY`gi Va]gg]cbg`[i]XY`]bYg/
- fYj]Yk 'cZa Uf_g/
- I BGK '< YU'h\ 'UbX'GUZYhm'dc']W]Yg/
- YI Ua]bUh]cb dfcWYXi fYg/
- gdYWJU``Wcbg]XYfUHjcb']b'H\Y'Yj YbhcZ]``bYgg'cf'a]gUXj Ybh fY/