

LING5001

GYWcbX~@Ub[iU[Y~5Wei]g]h]cb

GYa YghYf'C bY''##'&\$%

7ci fgY[·]Cj Yfj]Yk

GHJZZ:7cbHJWh:8YHJ]`g`

7cbj Ybcfg

B Ua Y	9a U]`	5j U]`UV]`] m	@cWUh]cb	D\cbY
>Ua Yg [·] @YY	Ua Yg"`YY4 i bgk "YXi "Ui			

: cf`YggYbhJU``ghi XYbh`]bZcfa UhJcb`fY`UhJb['hc. 'fYei Yghg`Zcf`Yl hYbg]cb/fYj]Yk 'cZa Uf_g/cWW dUhJcbU``\YU`h\UbX`gUZYhm'Yl Ua]bUhJcb'dfcWYXi fYg/gdYWJU``Wcbg]XYfUhJcb`]b'h\Y'Yj YbhcZ]``bYgg`cf`a]gUXj Ybhi fY/ghi XYbhYei]hmUbX`X]gUV]`]hm'UbX`ch\Yf`YggYbhJU``UWUXYa]W]bZcfa UhJcbž gYY`\hdg.#k k k "Ufhg"i bgk "YXi "Ui #W ffYbhghi XYbhg#JWUXYa]W]bZcfa UhJcb#dfchcWc`g![i]XY`]bYg#

7ci fgY 8YHJ] g

7 fYX]hDc]bhg * *

Gi a a UfmcZh\Y 7ci fgY

Gi VYWh5fYU. @b[i]gh]Wg

H\]g`Wci fgY`ZcW gYg`cb`UWei]g]h]cb'h\UhiH__Yg`d`UW`]b`]bghfi WhX`gYhf]b[g`UbX`Wcbg]XYfg`Vch\`W\]X`UbX UXi `hgYWcbX``Ub[i U[Y`UWei]g]h]cb''`Mci `k]``YI d`cfY`fYgYUfW\`UbX`Udd`mh\Ycf]Yg`cZgYWcbX``Ub[i U[Y UWei]g]h]cb'hc']bghfi WhX`WcbhYI hg''`Mci `k]``YI d`cfY`U'j Uf]YmmcZh\Ycf]Yg`UbX`a Ubmj Uf]UV`Ygžgi W\`Ug]bX]j]Xi U``X]ZZYfYbWrgž'h\Uhi]bZi YbWr']bghfi WhX`gYWcbX``Ub[i U[Y`UWei]g]h]cb'Vch\`Ug`U'dfcWrgg`UbX`Ug`U dfcXi Wh'Mci `k]``YI Ua]bY`bchcb`mh\Y`gYWcbX``Ub[i U[Y`UWei]g]h]cb'cZ9b[`]g\`Vi hcZch\Yf``Ub[i U[Y`Ug kY``''Mci `k]```Wca Y`hc'i bXYfghJbX`h\Y`ZJWcfg`h\Uhi]bZi YbWr'h\Y`fci hY`UbX`fUhY`cZUWei]g]h]cb'Ug`kY```Ug h\cgY`h\UhiUZYWhU`YUfbYffjji`i `h]a UhY`UhhJ]ba Ybh'

5 hith Y WcbWi g]cb cZhh]g Wci fgY hh Y ghi XYbhik]``VY UV Y hc

- %" 9 I d`U]b`h\Y`j Uf]ci g`dfcWfggYg`UbX`dfcXi Wfg`cZ]bglfi WfYX`gYVcbX``Ub[i U[Y`UWei]g]h]cb" &" A U_Y`i gY`cZUddfcdf]UhY`hYfa]bc`c[mhc`X]gWigg`_YmWcbWfdhg`]b`]bglfi WfYX`gYVcbX``Ub[i U[Y UWei]q]h]cb"
- " #bh/fdfYhfYgYUfVX ZjbX]b[g:UbX:Udd`mh\Ya hc]bghfi WhjcbU`WcbhYl hg"
- ("5ggYgg;h\Ya Yf]hg;cZj Uf]ci g;UddfcUW\Yg;hc;fYgYUfW\]b[;]bghfi WhYX;gYWcbX;``Ub[i U[Y;UWei]g]h]cb"

HYUWX]b[GhfUhY[]Yg

 $GYWcbX``Ub[iU[Y`UWei]g]h]cb`]g`U`_YmUfYU`cZ5dd`]YX`@]b[i]gh]Wg''`H\]g`WcifgY`ZcWigYg`cb`UWei]g]h]cb`h\UhHU_Yg`d`UWY`]b`]bghfiWhYX`gYhf]b[g`UbX`Wcbg]XYfg`Vch\`W\]X`UbX`UXi`hgYWcbX``Ub[iU[Y`UWei]g]h]cb''``$

H\Y`Wci fgY`Zcfa Uh`]g`h\UhcZU`gYa]bUf`]b`k\]W\`dfYdUfUhJcb`df]cf`hc`UhhYbX]b[`WUgg`]g`YggYbhJU``hc a YUb]b[\Z\`mX]gW\gg]b[`Wci fgY`WcbhYbh'Ghi XYbhg`UfY`Ugg][\bYX`k\YY_`mfYUX]b[\g`h\Uh\Zcfa \h\Y`VUg]g`cZ\WUgg`X]gW\gg]cb"`H\Y`hYghg`gYfj\Y`hc`\Uj\Y`ghi XYbhg`gmbh\Yg]nY`UbX`Yj\U`i\UhY`Wci fgY`WcbhYbh'h\Y\dfYgYbhUhJcb"]nY`UbX`Yj\U`i\UhY`Wci fgY`WcbhYbh'h\Y\dfYgYbhUhJcb"H\Y`Z]bU``YggUmU``ck\g`ghi XYbhg`hc\Id`cfY`Ub`]qqi\Y`cZdYfqcbU``]bhYfYqh'i`

Gi Va]gg]cb cZ5ggYgga YbhHUg_g

Gh XYbhg UfY Yl dYWYX hc di hh\Y]f bUa Yg UbX gh XYbhbi a VYfg cb Yj YfmdU[Y cZh\Y]f Ugg][ba Ybhg"

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

Imagi YbWci bhYf'U'dfcV'Ya 'k \Yb'UthYa dr]b['rc'gi Va]hmci f'Ugg][ba Ybht\fci [\'Hi fb]r]bž'd'YUgY hY'Yd\cbY'9I hYfbU'Gi ddcfhcb'-',) "''' %cf'Ya U] hYa 'cb'<u>Yl hYfbU'hY'hgi ddcfh4 i bgk "YXi "Ui"</u> "Gi ddcfh \ci fg'UfY', .\$\$Ua '-'%\$.\$\$da 'cb'k YY_XUmg'UbX'-.\$\$Ua '-') .\$\$da 'cb'k YY_YbXg'fl *) 'XUmg'U'mYUft'" Imai UfY'i bUV'Y 'rc'gi Va]hmci f'Ugg][ba YbhXi Y'rc'U'ZJi 'hk]h\ 'Hi fb]h]b'mci 'a UmUdd'mZcf'Ub'YI hYbg]cbž'Vi hmci a i ghfYhJ]b'mci f'h]W_Yhbi a VYf'Zfca '9I hYfbU''Gi ddcfhfU'cb['k]h\ 'Ubmch\Yf'YYj UbhXcW a Ybhgt'rc]bWi XY'Ug'Yj]XYbW' 'rc'gi ddcfhmci f'Yl hYbg]cb'Udd']WUh]cb" Imai 'Ya U]''9I hYfbU''Gi ddcfhmci 'k]'`Ui hca Uh]WU''mfYWf]j Y'U'h]W_Yhbi a VYfž'Vi h]Zmci 'hY'Yd\cbY'mci 'k]'''bYYX'rc'gdYW]ZWU''mUg_'Zcf'cbY" Hi fb]h]b'U'gc'dfcj]XYg'i dXUhYg'cb'h\Y]f'gmghYa 'ghUh' g'cb'Hk]hYf"

; YbYfU`mž'UggYgga YbhitUg_g'a i ghVY'gi Va]hhYX'Y`YWfcb]WU``mj]U'Y]h\Yf'Hi fb]h]b'cf'U'A ccX`Y Ugg][ba Ybh''=b']bghUbWfg'k \YfY'h\]g']g'bchdcgg]V`Yž']hk]```VY'ghUhYX'cb'mci f'Wci fgY'g'A ccX`Y'g]hY'k]h\U`hYfbUh]j Y'gi Va]gg]cb'XYhU]`g"

@UhY 5ggYgga Ybh'DYbU`h]Yg

5b'UggYggYX'HUg_']g'XYYa YX``UhY']Z]h']g'gi Va]hhYX'UZhYf'h\Y'gdYW]Z[YX'h]a Y'UbX'XUhY'Ug'gYhci h']b'h\Y Wci fqY'@YUfb]b['A UbU[Ya YbhGmqhYa 'f@A GŁ"

 $\label{thm:condition} $$HY^UHY^dYbU^m]g^hY^cgg^cZ)_L^cZ^hY^hcHU^dcgg]VY^aUf_g^Zcf^hYY^HUg_Z^cf^YUW^XUmcf^dUfhhYfYcZhY^kcf_]g^UHY^@UhYbYgg^k]^*]bW^XY^kYY_YbXg^UbX^di_V^]WYc^]XUmg^"HY]g^XcYg^bchUdd^mhc^U'HUg_'hWh]g^UqqYqqYX^Vi_hbc^a_Uf_]g^Uk_UfXYX"$$$

K cf_'gi Va]hhyx'zci fhyyb'fl%(EXUmg'Uzhyf'h\y'Xi Y'XUhy'k]``VY'a Uf_YX'UbX'zYYXVUW_'dfcj]XYX'Vi hbc'a Uf_ k]``VY'fYWcfXYX"'=Zh\Y'k cf_'k ci `X'\Uj Y'fYWr]j YX'U'dUgg'a Uf_'Vi hzcf'h\Y'`UhybYgg'UbX'h\Y'k cf_']g'U Wca di `gcfm'Wci fgY'Wca dcbYbhz'U'gh XYbh'k]``VY'XYYa YX'hc'\Uj Y'a Yhih\UhfYei]fYa Ybh''H\]g'XcYg'bch Udd`mhc'U'hUg_'h\Uh']g'UggYggYX'Vi hbc'a Uf_']g'Uk UfXYX"

K cf_'gi Va]hh/X'hk YbhnlcbY'f&&XUmg'UZhYf'h\Y'Xi Y'XUhY'k]``'bchVY'UWWdhYX'Zcf'a Uf_]b['cf'ZYYXVUW_UbX'k]``'fYWY']j Y'bc'a Uf_'cf'[fUXY"'=Zh\Y'UggYgga YbhHUg_']g'U'Wca di `gcfmWca dcbYbhcZh\Y'Wci fgY'U ghi XYbhk]``'Ui hca UhJWU``mZJ]`'h\Y'Wci fgY"

GdYWJU`7cbg]XYfUhJcb55dd`]WUhJcbg

 $\label{eq:linear_continuity} $$Mc_i = W_0 - W_$

G]W_bYggža]gUXj Ybhi fY'cf'ch\Yf'W]fW a ghUbWrg'VYmcbX'mci f'Wcbhfc``a Um

ł DfYj Ybhimci Zfca Wca d`Yhlb[U.Wci fqY fYei]fYa Ybhž

ł? YYd mci Zfca 'UthYbX]b['Ub 'UggYggUV`Y 'UWhj]tmž

ł Ghod moi gi Va]hh]b['UggYggUV'Y k cf_ Zcf'U Wci fgYž

ł `G][b]Z]\WbhmUZZY\Wimci f`dYfZcfa Ub\Wf`]b`UggYggUV`Y`k cf_ž`VY`]h'U`Zcfa U``YbX!cZgYa YghYf`Yl Ua]bUh]cbž'U \WUgg`hYghz`U``UVcfUhcfmhYghz`U`gYa]bUf`dfYgYbhUh]cb`cf`Ubmch\Yf`Zcfa 'cZ`UggYgga Ybh'

: cf'Z ft\Yf'XYfU]'g']b'fY`Uf]cb'fc'GdYW]U`'7 cbg]XYfUf]cb']bWl X]b[''"K \Yb'fc'5dd`m"ž'"<ck'fc'5dd`m"'UbX "Gi ddcft]b['8cWla YbfUf]cb'''d`YUgY'fYZYf'fc'f\Y'GdYW]U`'7 cbg]XYfUf]cb'k YVgf]Y.'\\fdg.#gh XYbf'i bgk "YXi"Ui #gdYW]U`!Wcbg]XYfUf]cb

$5\,WUXYa~]W< cbYghmUbX~D~U[~]Uf]ga$

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"`±hWJb`hU_Y`a Ubm Zcfa gžZfca `XY`]VYfUhY`W\YUh]b['hc`UWW]XYbhJ``mWcdm]b['Zfca `U`gci fWY`k]h\ci hUW_bck `YX[Ya Ybh'

 $I\ B\ G\ K\ [fci\ dg'd`U[\]Uf]ga\ []bhc'h\ Y'\ Zc``ck\]b[\ 'WUhY[\ cf]Yg.$



7ci fgY GWXYXi `Y

J]Yk 'WUgg'ha YHUV'Y

H]a YtUV`Y

8 UHY	Hmd Y	7 cbhYbh
K YY_'%'&*': YVfi Ufm!'(A UfWX	GYa]bUf	%"∵±olfcXi Wijcb
		Cj Yfj]Yk
		&"``7\UdhYf`%"`@Ub[iU[Y`@YUfb]b[`]b`9Uf`m 7\]`X\ccX
		' "'F YgYUfW\'fYUX]b['%
K YY_'&.') 'A UfWX'! '%% A UfWX	GYa]bUf	8 JgW gg]cb
		%"·7\UdhYf`%"·@Ub[i U[Y`@YUfb]b[`]b`9Uf`m 7\]`X\ccX
		&"'F YgYUfW\\fYUX]b['%
		C j Yfj]Yk
		' "`7\UdhYf`&"`GYWbX`@Ub[i U[Y`@YUfb]b[
		("'F YgYUfWX'fYUX]b['&
K YY_" ."&"A UfWX"!"% A UfWX	GYa]bUf	8 JgW gg]cb
A UIVW		%"``7\UdhYf`&"'GYWcbX'@Ub[iU[Y'@YUfb]b[
		&"`F YgYUfVX`fYUX]b[`&
		C i Vfi IVk
		C j Yfj]Yk
		' "``7\UdhYf`("`9 d`U]b]b[`GYWbX`@Ub[iU[Y @YUfb]b[
		("'F YgYUfV% 'fYUX]b[''
K YY_'(,'%-'A UfVX'!'&) A UfVX	GYa]bUf	8 JgW gg]cb
		%"``7\UdhYf`("`9 d`U]b]b[`GYWcbX`@Ub[iU[Y @YUfb]b[
I	I	I

1		&"'F YgYUfW\'fYUX]b[''
		C j Yfj]Yk
		' "`7 \UdhYf" "`±bX]j]Xi U``8]ZZYfYbWYg`]b`GYWcbX @Ub[i U[Y`5Wei]g]h]cb
K YY_').'&*'A UfWX'!'% 5df]`	5ggYgga Ybh	±bWUgg'HYgh''7cjYfg'7\UdhYfg'% ('UbX'FYgYUfV\\FYUX]b[g'% '"
6fYU^&^5df]^^!^, ^5df]		
K YY_'*.'- '5df]`'!'%) '5df]`	GYa]bUf	K YY_'*']g'U`gc'U'6F95?'k YY_'Zcf'Dcgh[fUXi UhY Wci fgYg"
K YY_'+.'%*'5df]`'!'&& 5df]`	GYa]bUf	FYUX'df]cf'hc'Wca]b['hc'WUgg.
		%"`7\UdhYf`)"'CVgYfj]b['@YUfb]b['UbX'HYUW\]b[']b h\Y'GYWcbX'@Ub[iU[Y'7`Uggfcca
		&"`F YgYUfW\`fYUX]b['(
K_YY_', .`&' `5df]`'!`&- 5df]`	GYa]bUf	FYUX'df]cf'hc'Wca]b['hc'WUgg.
		%"`7\UdhYf`*"`G]I`DfcdcgU`g`Zcf`GYWcbX`@Ub[iU[Y HYUW\]b[
		&"'F YgYUfW\'fYUX]b[')
K YY_''' \$'5df]`'!'*'A Um	GYa]bUf	FYUX'df]cf'hc'Wca]b['hc'WUgg.
		%"'F YgYUfWX 'fYUX]b['*
		&"`F YgYUfW\`fYUX]b[`+
K YY_'%\$.'+'A Um!'% A Um	GYa]bUf	FYUX'df]cf'tc'Wca]b['tc'WUgg.
A OIII		%" F YgYUfWX fYUX]b[',
		&"`F YgYUfW\`fYUX]b['-
K_YY_'%%''%('A_Um!' &\$ A_Um	GYa]bUf	FYUX'df]cf'hc'Wca]b['hc'WUgg.
		%"F YgYUfW\"fYUX]b['%\$
		&"`F YgYUfW\`fYUX]b[`%%
K YY_'%&.'&%A Um!'&+ A Um	GYa]bUf	FYUX'df]cf'hc'Wca]b['hc'WUgg.
		%"'F YgYUfW\'fYUX]b['\&
		&" ·F YgYUfW\ ·fYUX]b[·%
K YY_'% .'&, 'A Um!'' >i bY		±bWUgg`HYgh`Wcj Yfg`7 \ UdhYfg`)!* `UbX`F YgYUfW\ F YUX]b[g`(`!`% "

F Ygci fWg

DfYgWf]VYX F Ygci fWg