



# MECH4100

A YVX Ub]WU`8 Yg][ b`&

HYfa `Hk c`##`&\$&%

GWXcc`cZA YVX Ub]WU`UbX`A Ubi ZUW f]b[ `9b[ ]bYYf]b[ `##`I BGK `9b[ ]bYYf]b[

7ci fgY`Cj Yfj ]Yk

GHJZ`7cbHJW`8YHJ]`g

7cbj Ybcfg

B Ua Y	9a U]	5j U]UV]`]m	@cW]h]cb	D\cbY
=fYbY`F YbUi X! 5ggYa Uh	]`fYbUi XUggYa Uh4 i bgk "YXi "Ui	- Ua !) da žA cb!: f]	5]bgk cftλ 6i ]X]b[ `>%+ž F cca `&\$, 7	

@YW`i fYfg

B Ua Y	9a U]	5j U]UV]`]m	@cW]h]cb	D\cbY
8Ub]Y`9[ (	]bgk cftλ			

fZ \*%&E- ' , ) '' %+- '-I BGK `Gh Xm5VfcUX`UbX`I BGK `9I WUb[ Y`fZcf`]bVci bX`gh XYbhgk

fZ \*%&E- ' , ) `(\$- +'-GWcc`C Z]W}t

†D`YUgY`bchY`hUhihY`GWcc`C Z]W`k ]`bch\_bck`k \Yb#Zmc i fWci fgY`Wcbj Ybcf`]g`cb`Wla di g`cf  
Uj U]UV`Y

9a U]`

[9b\[ \]bYYf\]b\[ `Gh XYbhGi ddcfhGYfj \]Wg`-`W ffYbhghi XYbhYbei \]f\]Yg](#)

•

7ci fgY'8YHJ]`g

7fYX]hDc]bmg`\*`

Gi a a UfmicZh\Y'7ci fgY

h`h]g`Wci fgYžgh XYbmg`k`i`i` bXYfU\_Y`U`a` U`f`XYg][`b`dfc`YWh`Ug`U`h`Ua` ž`YbUV`]b[`h`Ya`h`c`XYj`Y`cd`  
W`b`W`dh`U`UbX`XYHJ]YX`gc`i`h`cbg`Z`f`Ub`Yb[`]b`Y`f`b[`]d`f`c`Y`W`ž`i`h`]n]b[`]UbX`Yi`h`bX]b[`]h`Y]f`\_`bck`YX[`Y`UbX`  
g\_]`g`U`V`ei`]f`YX`h`f`ci`[`\`ci`h`h`Y`XY[`f`Y`Y`d`f`c[`f`Ua`a`Y`H`g]b`W`i`XYg`d`f`c`Y`W`i`V`U`g`Y`X`XYg][`b`d`f`c`W`g`g`ž`d`f`c`Y`W`  
a`UbU[`Ya`Y`b`ž`XYg][`b`Z`f`a`U`bi`Z`J`W`i`f]b[`]ž`f`Y`UV`]m`ž`U`Z`c`f`X`U`V`]m`ž`U`b`X`gi`g`h`U]b`U`V`]m`i`

Z`U`W`Y`U`h`g`k`ž`g`h`f`Y`U`b]h`W`A`Y`Z`c`k]W`h`U`f]b[`]U`b`X`]b`W`B`i`U`h`a`]b[`]h`h`Y`c`j`Y`f`U`U`W`h`j`]h`Y`g`c`Z`h`Y`h`Y`Ua`ž`U`g`%`d`%`g`  
W`c`f`X]b`U`h`h`Y`c`j`Y`f`U`X]f`Y`W`h`c`b`c`Z`h`Y`h`Y`Ua`ž`U`b`X`f`Y`d`c`f`h`h`Y]f`d`Y`f`Z`f`a`U`b`W`h`f`ci`[`\`d`f`c`h`m`d`Y`  
a`U`bi`Z`J`W`i`f]b[`]U`b`X`h`Y`g]b[`]ž`k`f]h`Y`b`XY` %`o` Y`














F Ygci fWg

F YWca a YbXYX'F Ygci fWg

Gi [ [ YghYX'fYUX]b[ 'fU'ghUfh]b[ 'dc]bhcb`mŁ

9I WY`YbhUXj ]WzXYgW[dh]cbg'UbX'[ i ]XY`bYgžVUgYX'cb'dfUW]WU`YI dYf]YbWY'UFY'[ ]j Yb`]b`? S] [ Y'E f[d] Y  
7` Y[ Wē Vm5bXmF cggžk \]VW`Wb`VY`cVhU]bYX'Ug'U`ZY`Xck b`cUX'Zca`h\Y`Zc`ck ]b[  
dU[ Y.

Gi Va ]gg]cb'cZ5ggYgga YbhiHUg\_g

5ggYgga Ybhgi Va ]gg]cb'UbX'a Uf\_]b[ 'Wf]hYf]U

G\ci 'X'h\Y'Wci fgY'\Uj Y'Ubmbcb!Y'YVWfcb]WUggYgga Ybhgi Va ]gg]cbž'h\YgY'g\ci 'X'\Uj Y'U'ghUbxUfX  
GWkcc'Wcj Yf'g\YYH'

5`gi Va ]gg]cbg'UfY'YI dYVWYX'hc'VY'bYUhiUbX'WYUfmgYhici H'Mci f'fYgi 'hg'UfY'h\Y'd]bbUWY'cZU`mci f'\UfX  
k cf\_'UbX'g\ci 'X'VY'hYUhiX'k ]h'Xi Y'fYgdYVW'DfYgYbh]b[ 'fYgi 'hg'WYUfm[ ]j Yg'h\Y'a Uf\_Yf'h\Y'VYghWUbxW  
cZi bXYfgUbx]b[ 'mci f'a Yh\cX/Yj Yb']Zh\Y'bi a Yf]WU'fYgi 'hg'UfY']bVc'ffYVW'

A Uf\_]b[ '[ i ]XY']bYg'Zcf'Ugg][ ba Ybhgi Va ]gg]cbg'k ]`VY'dfcj ]XYX'Uhih\Y'gUa Y'h]a Y'Ug'Ugg][ ba YbhXYH]g  
hc'Ugg]ghk ]h'a YH]b[ 'UggYggUV'Y'fYei ]fYa Ybhg" Gi Va ]gg]cbg'k ]`VY'a Uf\_YX'UWVc'fX]b[ 'hc'h\Y'a Uf\_]b[  
[ i ]XY']bYg'dfcj ]XYX"

@UHY'dc`]Wm

K cf\_gi Va ]hYX'UH'k ]h\ci hUb'Uddfcj YX'YI hYbg]cb'Vmih\Y'Wci fgY'Wc'fX]bUhc'f'c'XY'Y[ UHYX'Ui h\cf]hm]g  
gi VYVWih'U'UH'dYbU'micZ&\$'dYfW'bhf&\$i 'E'cZh\Y'a U] ]a i a 'a Uf\_'dcgg]V'Y'Zcf'hUhiUggYgga Ybh]hYa ž  
dYf'WU'YbXUf'XUm'

H\Y'UH'dYbU'mi]g'Udd'YX'dYf'WU'YbXUf'XUm]bWi X]b[ 'k YY\_YbXg'UbX'di V]W\c'XUmg'U'Uhih\Y  
UggYgga Ybh]g'c] YfXi Y'"H\YfY'g'bc'dfc!fUHU'cZh\Y'UH'dYbU'miZcf'gi Va ]gg]cbg'a UXY'dUfhk Umih\ci [ '\U  
XUm'

K cf\_gi Va ]hYX'UZf'h\Y'XYUX']bY'Zcf'UVgc'i h'ZU]' ]g'bchUWVW'dhYX'UbX'U'a Uf\_'cZnYfc'k ]`VY'Uk UfXYX  
Zcf'hUhiUggYgga Ybh]hYa "

: cf'gca Y'UggYgga Ybh]hYa gžU'UH'dYbU'mia UmibchVY'Uddfcdf]UH'" H\YgY'UfY'WYUfm]bX]WUhiX']b'h\Y  
Wci fgY'ci h]bYž'UbX'gi W'UggYgga Ybhg'fYVW'j Y'U'a Uf\_'cZnYfc']ZbchWca d'YhX'Vmih\Y'gdYVW]ZYX'XUH'"  
9I Ua d'Yg']bWi XY.

% K YY\_'micb']bY'hYgh'cf'UVcfUhc'fmik cf\_'k cff'h'U'ga U'dfc'dcf]cb'cZh\Y'gi VYVWia Uf\_ž'cf  
&" C b']bY'ei ]nnYg'k \YfY'Ubgk Yfg'UfY'fY'UgYX'hc'gfi XYbhg'cb'Wca d'Yh]cbž'cf  
' " DfcZYgg]cbU'UggYgga YbhHUg\_gžk \YfY'h\Y']bhYbh]cb ]g'hc'WYUhi'Ub'Ui h\Ybh]WUggYgga Ybh'h\U  
\Ug'Ub'UVgc'i h'gi Va ]gg]cb'XUH'ž'cf  
(" DUgg# U]'UggYgga YbhHUg\_g"

9I Ua ]bUH]cbg

UggYgga YbhdYfZcfa UbWžmci 'UfY'Y'[ ]V'Y'hc'Udd'mZcf'GdYWU'7 cbg]XYfUhc'b'df]cf'hc'gi Va ]h]b[ 'Ub  
UggYgga Ybhcf'g]h]b[ 'Ub'YI Ua "

I BGK 'bck '\Ug'U': [\]h\]c'G\]h#Gi Va \]hfi\\_Yžk \\]](#)W'a YUbg'hUh]Zmci 'UfY'a dhUb'YI Ua 'cf'gi Va ]hU'd]YW'cZ  
UggYgga Ybhž'mci 'UfY'XYWUf]b[ 'mci fgY'Z]hYbci [ '\ 'hc'Xc'gc'UbX'WUbbch'UfY'Udd'mZcf'GdYWU'  
7 cbg]XYfUhc'b"

: cf'XYHU]g'cZUdd'm]b[ 'Zcf'GdYWU'7 cbg]XYfUhc'b'UbX'WcbX]h]cbg'Zcf'hY'Uk UfX'cZgi dd'Ya YbhUfm  
UggYgga Ybhž'd'YUg'gYY'hY'jbZcfa Uhc]b'cb'I BGK 'g' [GdYWU'7 cbg\]XYfUhc'b'dU\[ Y"](#)

D'YUgY'bc'hY'hUhighi XYbhg'k ]'bchVY'fYei ]fYX'hc'dfcj ]XY'UbmXcW a YbhUfmYj ]XYbW'hc  
gi ddcfhUVgYbW'g'Zca 'UbmWUggYg'a ]ggYX'VYWU]i gY'cZ7CJ -8!%- 'di V']W\YU'h'a YUgi fYg'gi W'Ug  
]gc'Uh]cb" I BGK 'k ]'bchVY' ]bg]gh]b[ 'cb'a YX]W'Wf]h]WUhg'Zca 'UbmcbY'XYa YX'hc'VY'U'dcg]h] Y'WUgYž  
cf'k \Yb'hYm\Uj Y'fYVčj YfYX" 'Gi W'Wf]h]WUhg'UfY'X]Z]W'h'hc'cVHU]b'UbX'di hUb'i bbYW'ggUfmgfU]b'cb  
gh XYbhg'UbX'a YX]W'ghUZZ'

5dd']W]h]cbg'Zcf'gdYWU'Wcbg]XYfUhc'b'k ]'VY'fYei ]fYX'Zcf'UggYgga YbhUbX'dUf]h]W]dUhc'b'UVgYbW'g'—  
Vi hbc'XcW a YbhUfmYj ]XYbW'Zcf'7CJ -8 %- ]'bYgg'cf']gc'Uh]cb'k ]'VY'fYei ]fYX"

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

I BGK `Ug`Ub`cb[c]b[ `Wca a ]ha Ybhlc`ZcghYf]b[ `U`W`h`fY`cZ`YUfb]b[ `]bZcfa YX`VmiUWUXYa ]W]bhY[ f]m`5`  
I BGK `gh`XYbhg`Uj`Y`U`fYgdcbg]V`]mhc`UX`YfY`hc`h`g`df]bW]d`Y`cZUWUXYa ]W]bhY[ f]m`D`U[ ]Uf]ga  
i bXYfa ]bYg`UWUXYa ]W]bhY[ f]m]UbX`]g`bchlc`YfUHX`Uhl`BGK`"B`SY[Sde\_`SfG@E|`[e VWX` VW`Se ge[`Y`  
fZWi`ad/e`ad[VWSe`aXafZW`S`V`bSee[`Y`fZW`\_`aXSe`kagdai` `z`

D`U[ ]Uf]ga `]g`U`hmdY`cZ]bhY`YW`i`U`h`YZ`h`#`hW]b`hU`\_`Y`a`UbmiZcfa`gZ`Zca`XY`]VYfUHX`WX`YU]b[ `hc`UWUXYbH`U`m`  
W`dm]b[ `Zca`U`gci`fW`k`]h`ci`hUW`bck`YX[`Ya`Ybh`I`BGK` `Ug`dfcXi`WX`U`k`YVg]h`k`]h`U`k`YU`h`cZ`  
fYgci`fW`g`hc`gi`ddcfhgh`XYbhg`hc`i`bXYfgHUbX`UbX`Uj`c]X`d`U[ ]Uf]ga`z`j`]g]h`[gh`XYbh`i`bkg`"YXi`"Ui`#d`U\[ \]Uf\]ga`"](#)  
H`Y`@YUfb]b[ `7`YbhY`Ugg]ghg`gh`XYbhg`k`]h`i`bXYfgHUbX]b[ `UWUXYa ]W]bhY[ f]m]UbX`ck`bchlc`d`U[ ]Uf]gY`  
H`Y`miU`gc`lc`X`k`cf`g`cdg`UbX`W]b`Y`d`gh`XYbhg`cbY!cb!cbY`"

Mci`U`fY`U`gc`fYa`]bXYX`h`UhWUfYZ`h`a`Y`a`UbU[`Ya`Ybh]g`Ub`]a`dcfHUbhdUfhcZgh`XmiUbX`cbY`cZ`h`Y`  
]XYbh]ZYX`W]i`gYg`cZ`d`U[ ]Uf]ga`]g`d`ccf`h`a`Y`a`UbU[`Ya`Ybh`G`h`XYbhg`g`l`ci`X`U`ck`gi`Z]W]Ybh]h`a`Y`Z`c`f`  
fYgYUfWX`Z`X`fU`Z]b[ `UbX`h`Y`dfcdYf`fY`Z`fY`bW]b[ `cZ`gci`fW`g`]b`dfY`dUf]b[ `U`UggYgga`Ybh]Ug`g`"

Z`d`U[ ]Uf]ga`]g`Z`ci`bX`]b`mci`f`k`cf`\_`k`Y`b`mci`U`fY`]b`Z]fghmY`Uf`Z`mci`f`Y`W`h`fY`f`k`]`c`Z`Y`f`mci`Ugg]ghU`bW`hc`  
]a`dfcj`Y`mci`f`UWUXYa ]Wg`\_]`g`"H`Y`ma`UmUg`\_`mci`hc`cc`\_`Uh`gca`Y`cb`]bY`fYgci`fW`gZ`U`h`Y`bX`h`Y`@YUfb]b[`  
7`YbhY`Z`cf`gca`Y`h`a`Yg`fYgi`Va`]h`mci`f`k`cf`\_`k`]h`h`Y`dfcV`Ya`Z]`YX`"<ck`Yj`Yf`a`cfY`gYf]ci`g`]bgHUbW`g`]b`Z]fgh`  
mY`Uf`Z`gi`W`Ug`gh`U`]b[ `Ubch`Y`f`gh`XYbhg`k`cf`\_`cf`dU]b[ `gca`YcbY`hc`Xc`mci`f`k`cf`\_`Z`a`UmVY`]bj`Ygh[`U`h`X`  
i`bXYf`h`Y`G`h`XYbhA`]gW`cbXi`W`h`D`fcW`Xi`fYg`"

F`YdYU`h`X`d`U[ ]Uf]ga`fYj`Yb`]b`Z]fghmY`Uf`Z`d`U[ ]Uf]ga`U`Z`Y`f`Z]fghmY`Uf`Z`cf`gYf]ci`g`]bgHUbW`g`Z`a`UmU`gc`VY`  
]bj`Ygh[`U`h`X`i`bXYf`h`Y`G`h`XYbhA`]gW`cbXi`W`h`D`fcW`Xi`fYg`"H`Y`d`Y`b`U`h`Y`g`i`bXYf`h`Y`dfcW`Xi`fYg`W]b`]bW`i`XY`  
U`fY`Xi`W`h`cb`]b`a`Uf`g`Z`Z]b[ `U`W`ci`fgY`cf`Z`cf`h`Y`a`cghgYf]ci`g`a`U`h`Y`fg`f]`\_`Y`d`U[ ]Uf]ga`]b`Ub`l`cbci`fg`  
h`Y`g]g`L`Yj`Yb`gi`gdYbg]cb`Zca`h`Y`i`b]`Yfg]m`H`Y`G`h`XYbhA`]gW`cbXi`W`h`D`fcW`Xi`fYg`UfY`Uj`U]UV`Y`Y`fY`.

[k`k`k`"\[`g`"i`bkg`"YXi`"Ui`#d`\]W`h`c`W`a`Ybhg`gh`XYbhA`\]gW`cbXi`W`h`D`fcW`Xi`fYg`"dXZ`](#)

5 WUXYa ]W=Zcfa Uh]cb

7 fYX]hdc]bhg

7 ci fgY`WYX]hg`W`W`UH`X`]b`I` b]hg!C Z 7 fYX]hfl C 7 E`H`Y`bcfa U`k cf`cUX`YI dYWUh]cb`Zf`cbY`I C 7

- [AccXY](#)
- [@UV5WYgg](#)
- [7ca di hb\[ : UW\]hYg](#)
-

5ddYbX|l . '9b[ ]bYYfg'5i ghfU`U'f95E'DfcZYgg]cbU`'9b[ ]bYYf'7ca dYhYbWm  
 GHUbXUfX

Dfc[ fUa 'hYbXYX'@YUfb]b[ 'Ci hWta Yg	
? bck `YX[ Y'UbX'g_]`VUgY	
D9%"%7 ca dfY\Ybg]j YzhYcfmVUgYX'i bXYfghUbX]b[ 'cZhY'i bXYfd]bb]b[ 'bUh fU`UbX d\mg]WU`gWYbWg'UbX'hY'Yb[ ]bYYf]b[ 'Z bXUa YbH'g'Udd`]WUV'Y'hc'hY'Yb[ ]bYYf]b[ 'X]gWd`]bY	
D9%"&'7 cbWdh U`i bXYfghUbX]b[ 'cZhY'a UhYa Uh]Wg'z'bi a Yf]WU`UbU'mg]g'ghUhg]Wg'z'UbX Wta di h'f'UbX' ]bZ'fa Uh]cb'gWYbWg'k \]W' i bXYfd]b'hY'Yb[ ]bYYf]b[ 'X]gWd`]bY	
D9%" " 'h!XYdh'i bXYfghUbX]b[ 'cZgdYWU`]ghVcX]Yg'cZ_bck `YX[ Y'k ]h]b'hY'Yb[ ]bYYf]b[ X]gWd`]bY	
D9%"('8]gWfba YbhcZ_bck `YX[ Y'XYj Y`cda YbhUbX'fYgYUfW'X]fYW]cbg'k ]h]b'hY Yb[ ]bYYf]b[ 'X]gWd`]bY	
D9%" ) ? bck `YX[ Y'cZYb[ ]bYYf]b[ 'XYg][ b'dfUW]W'UbX'WcbhYI h U`ZUW'c'fg]a dUW]b[ 'hY Yb[ ]bYYf]b[ 'X]gWd`]bY	
D9%"* 'i bXYfghUbX]b[ 'cZhY'gWc'dYz'df]bW]d'Yg'z'bcfa g'z'UW]c'i bHUV`]h]Yg'UbX'Vci bXg'cZ gi gh]bUV'Y'Yb[ ]bYYf]b[ 'dfUW]W' ]b'hY'gdYW]ZWX]gWd`]bY	
9b[ ]bYYf]b[ 'Udd`]WU]h]cb'UV`]jm	
D9%"%5dd`]WU]h]cb'cZYghUV`]g\YX'Yb[ ]bYYf]b[ 'a Yh'cXg'hc'Wta d'YI'Yb[ ]bYYf]b[ 'dfcV'Ya gc`]b[	
D9%"&'&: 'i YbhUdd`]WU]h]cb'cZYb[ ]bYYf]b[ 'h'W]b]ei Yg'z'hc'g'UbX'fYgci fW'g	
D9%" " '5dd`]WU]h]cb'cZgmg]Ya Uh]WYb[ ]bYYf]b[ 'gmb'hYg]g'UbX'XYg][ b'dfcW'ggYg	
D9%"('5dd`]WU]h]cb'cZgmg]Ya Uh]WUdd'fcUW]Yg'hc'hY'WcbXi W]UbX'a UbU[ Ya YbhcZYb[ ]bYYf]b[ dfc'YW]g	
DfcZYgg]cbU`UbX'dYfgcbU`Uhf]Vi hYg	
D9' "%9h]WU`WcbXi W]UbX'dfcZYgg]cbU`UW]c'i bHUV`]jm	
D9' "&'9ZYW]j Y'cfU`UbX'k f]hYb'Wta a i b]WU]h]cb`]b'dfcZYgg]cbU`UbX`UmXca U]bg	
D9' "' '7fYUh]j Y'z]bbcj Uh]j Y'UbX'dfc!UW]j Y'XYa YUbcif	
D9' "( 'DfcZYgg]cbU`i gY'UbX'a UbU[ Ya YbhcZ]bZ'fa Uh]cb	
D9' )" 'C'fXYf'ma UbU[ Ya YbhcZgY'z]UbX'dfcZYgg]cbU`WcbXi W]	
D9' "*" '9ZYW]j Y'hYUa 'a Ya VYfg\]d'UbX'hYUa ``YUXYfg\]d	