

```
"#$%!&'(!)'*+'&!,-./$01%!$),.-2'*2!$*3.-)'2$.*!3.-!%2+O1*2%!O.$*4!$*O1,1*01*2!%2+O56!#.*.-%6!
'*07.-!%+) ) 1-!-1%1'-8#!$*!2#1!95#+%!: '(;!!<!1=,182!5.+!2.!3.&&.>!'&&!&'(!,-.810+-1%!'%!&'$0!.+2!
$\!2\#$\!O.8+\)1\*2:!!?\&1\\\1!-1\O!\$2!8\\-13+&\\5!\\*0!\\\1!\)1!\@\*.>!\\\3!5.+!\#\\1!\\*5!\A+1\\2\\3.\\\!.-!\\3!2\\1-1!
$\%!'*52\#$*4!<!\\#.+\&O!'00710\$2;!!!
! "#$%& "#
".!8-1'21!'*!$*8&+%$/1!&'(!8.))+*$25!>#1-1!1/1-5.*1B%!8.*2-$(+2$.*%!'-1!/'&+10!'*0!>1!'&&!#1&,!
'*0!%+,,.-2!1'8#!.2#1-;!!C%!'!>.) '*!8.4*$2$/1!*1+-.%8$1*2$%2!'*0!3$-%2D41*1-'2$.*!8.&\d141!%2+01*2!
&'(!(5!) '@$*4!1=,182'2$.*%!1=,&$8$2!$*!2#1!&'(!) '*+'&6!'&&.>$*4!3&1=$($&$25!(5!1*8.+-'4$*4!
%2+O1*2%!2.!>.-@!.*!2#1!'-1'!.3!-1%1'-8#!2#'2!$%!).%2!$*21-1%2$*4!2.!2#1)6!)'@$*4!%+-1!2#'2!
1/1-5.*1!$\\!4\$/1\*!2\\\1!..,.-2\+\$\\\25!2.!,'-2\\$\\$,'21!1A+'\&\\5!\$\\!2\\\1!\\\'(!'\*0!\$\*!\\\'(!) 112\\$\\4\\\\\!6!'\\82\\$\\\!4!'\\!
'*!'&&56!'*O!).01&$*4!$*8&+%$/$25!$*!2#1!&'(:!!C321-!-1'O$*4!2#1!&'(!)'*+'&6!,&1'%1!)112!>$2#!)1!
2.!0\%8+\%!\#.>!<!8'*!).\%2!133182\%/1&5!\%+,,.-2!5.+;!!!
".!4$/1!5.+!2#1!.,,.-2+*$25!2.!,'-2$8$,'21!$*!-1%1'-8#;!!<!>$&&!#1&,!5.+!01%$4*!5.+-!1=,1-$) 1*26!
2-'$*!5.+!$*!2#1!218#*$A+1%!+%10!$*!2#1!&'(.-'2.-56!'*0!2-'$*!5.+!'*0!,-./$01!3110('8@!.*!133182$/1!
.-1%1*2'2$.*!.3!-1%1'-8#:!!<!8'*!'&%.!#1&.!5.+!$01*2$35!'*0!'....'8#!'00$2$.*'&!) 1*2.-%!2.!'%%$%2!
5.+!>$2#!5.+-!-1%1'-8#:!
E+,...-2!5.+! *0!5.+-!8'-11-!4.'&%:!!<3!5.+!'-1!%2-+44&$*4!.-!$3!'*5!$\%+1\%!'-$\%1!\$*!2\#1!\&'(6!.\&1'\%1!)
8. ) 1!\%11! ) 1;!!"#1-1!'-1! ) '*5!-1%.+-81%!'2!F.>0.$*!2.!%+,,.-2!5.+-! ) 1*2'\&!'*0!, #5\\$8'&!
> 1&&*1%%!G%11!'O$2$.*'&!-1%.+-81%!(1&.>H:!!<!')!#',,5!2.!O$%8+%%!4-'O+'21!%8#..&6!-1%1'-8#!
....-2+*$2$1%!'321-!4-'0+'2$.*6!'*0!31&&.>%#$,%6!,-./$01!3110('8@!.*!',,&$8'2$.*%6!'*0!>-$21!5.+!
&1221-%!.3!-18.)) 1*0'2$.*;!!"#1-1!'-1!) '*5!-1%.+-81%!'2!F.>0.$*!2.!%+,,.-2!5.+-!8'-11-!4.'&%!
6%11!'O0$2$.*'&!-1%.+-81%!(1&.>H;!!".!-1A+1%2!'!&1221-!.3!-18.))1*O'2$.*!,&1'%1!4.!2.!
#22,I774..;4&73.-) %7 J #K%>/<L!'*0!%1*0!) 1!5.+-!+*.33$8$'&!2-'*%8-$,2;!!!
(%)*#$%&'#
M.*2-\$(+21!2.!'*!\$*8\&+\%\$/1!\&'(!8.))+*\$25!>#1-1!1/1-5.*1B\(18.*2-\$(+2\).*\%!'-1!/'&+10!'*0!#1\(18...)
'*O!%+,,.-2!1'8#!.2#1-;!!!
".!'82$/1&5!1*4'41!$*!2#1!-1%1'-8#;!!N1,1*0$*4!.*!2#1!-1%1'-8#!,-.0182!2#'2!5.+!'-1!$*/.&/10!$*!
5.+!) '5!'%%%2!>$2#!1=,1-$) 1*2'&!01%$4*6!-+*!(1#'/$.-'&!%+(0182%6!-+*!PPO!%+(0182%6!-+*!2CME!
%+(0182%6!'*'&5R1!(1#'/$.-!'*07.-!PPQ!0'2'6!,-1%1*2!5.+-!-1%1'-8#!G'%!'!2'&@!'*07.-!,.%21-H6!>-$21!
'!.'.1-!.*!5.+-!.-.01826!'*0!'221*0!-14+&'-!&'(!)112$*4%:!!S*81!5.+!#'/1!4'$*10!1=.1-$1*81!$*!
2#1!&'(6!<!1=,182!5.+!2.!(18.)1!).-1!$*01,1*01*2!$*!4+$0$*4!2#1!0$-182$.*!2#'2!5.+-!-1\%1'-8#!
2'@1%!'*O!1/1*2+'&&5!2'@$*4!.*!'!&1'O1-%#$,!-.&1!'*O!) 1*2.-$*4!.2#1-!%2+O1*2%!$*!2#1!&'(;!
```

!
F1!-1%, 1823+&!. 3!2#1!&'(!'*0!5.+-!&'(!) '21%;!!?&1'%1!@11, !2#1!&'(!%, '81!2\$056!2+-*!.33!'*0!, +2!'>'5!
5.+-!81&&!, #.*16!'*0!\$3!5.+!) +%2!+%1!'!&', 2.,!, &1'%1!2+-*!.33!5.+-!>\$3\$!3.-!'*5!&'(!'82\$/\$2\$1%!'*0!
&'(!) 112\$*4%;!!

! Q..4&1!8'&1*0'-I! $<*!'00\$2\$.*!2.!') 5!-1/\$1>!, ',1-!.*!.\%8\$\&\&'2\$.*\%!\$*!) 1).-5!6\underline{95\#+\%!} g !M+--'*6! \backslash WZWH;!!<!>.+\&0! -18.') 1*0!-1'0\$*4!'!31>!(..@\%!.*!.\%8\&\%'2\$.*\%;!!E5*8I! J.>!S-01-!P) 1-41\%!3-.) !M\#'.\%!\$*!2\#1! ^*\$/1-\%16!9'2+-16!'*0!N'\$\\$5!:\$31!4\$/1\%!'!41*1-'\&!./1-/\$1>!.*!.\\88\&\\%'2.-5!(1\#'/\$.-!\$*!*'2+-1! 63-.) !3\$-13\\$1\\%!2.!*1+-.*\\H6!]\#52\#') \\%!.3!2\#1!F-'\$*!0\$\%8+\\%1\\!.\%$

```
!
"#1!&'(!$%!%+,,.-210!(5!F.>0.$*!'*0!2#1!9<J;!!T1!%#.+&0!#'/1!'&&!2#1!1A+$,)1*2!'*0!%+,,&$1%!
5.+!*110!3.-!>.-@$*4!$*!2#1!&'(6!(+2!$3!5.+!*110!2.!(+5!%.) 12#$*4!.-!, '5!8.*31-1*81!311%6!5.+!0.!
*.2!#'/1!2.!+%1!5.+-!.>*!).*15;!!?&1'%1!8.*2'82!)1!'*0!<!8'*!,'5!3.-!$2!>$2#!)5!F.>0.$*!8-10$2!
8'-0:!
>*-:)-3'#/2?%%&#-.:#$'4'-*2?#@AA%*3).636'4#
C\&+) *\S!'*0!-1\%1'-8\#!...-2+*\$2\$1\%I!\#22,\%I77>>>;(.>0.\$*;10+78=07!
11%1'-8#!.,..-2+*$2$1%!'321-!4-'0+'2$.*I!#22,I77,%58#>$@$,'-2\;>$@$0.2;8.)7,-10.8%!
C_{1} = C_{1
C00$2$.*'&!PPQ!2-'$*$*4I!#22,%I77,+-%+1;-$8#).*0;10+7&$*@%7!
B).:6.7#
P) 1-41*85!3+*0*4!3.-!\%2+01*2\%I!\#22,\%I77>>>;(.>0.**;10+701'*D.3D
%2+01*2%7-1%.+-81%71) 1-41*85D3+*0$*47!
] 1\%1'-8\#!31\&\. >\\#\$,\\!'\*0!4-'\*2!>-\$2\$\*4I!\#22,\\I77>>>;(.>0.\$\*;10+7\\2+01\*2D
31&&. > %#$, %7$*O1=;#2) &!
9Eb!4-'0+'21!-1%1'-8#!31&\(\dagger) \sigma\(\dagger) \sig
 ! '.3-&#-.:#<?"462-&#C'&&.'44#
E2+05!\#'(\$2\%6!A+'*2\$2'2\$/16!>-\$2\$*46!'*0!2\$)1!)'*'41)1*2!\%+,...-2I!
#22, %I77>>>;(.>0.$*;10+7('&0>$*D81*21-7$*01=;#2)&!
[ 1*2'&!'*0!,#5%$8'&!#1'&2#I!#22,%I77>>>;(.>0.$*;10+78.+*%1&$*47!
C00\$2\$. * '\$!\$*3. - ) '2\$. * !\$, 18\$3\$8!2. !0. \$*4! '*!\$*01, 1*01*2!\%2+056!\#. * . -\%!, -.01826! . -!\%+ ) ) 1-!
-1\%1'-8\#!8'*!(1!3.+*0!(1\&.>:!
".!O.!'*!$*01.1*01*2!%2+05!5.+!>$&&!*110!2.!3$&&!.+2!2#1!-14$%2-'-B%!3.-)!
6#22, \$177>>>; (.>0.\$*;10+7-14\$\%2-'-7\%2+01*2\%78.+-\%1D-14\$\%2-'2\$.*7\$*01,1*01*2D\%2+O5;\#2) \&H!(5!2\#1!)
1*0!.3!'0070-.,!<:!!!C*!$*01,1*01*2!%2+05!$\!2'@1*!'\%!'!8.+-\%1!'*0!2\#1-13.-1!2\#1!1=,182'2\$.*!\$\!
2#'2!5.+!,+2!$*!'%!)+8#!2$)1!'%!5.+!>.+&O!3.-!'*5!.2#1-!8.+-%1!Gh!ZW!#.+-%!,1-!>11@H;!!''#$%!)'5!
/'-5!3-.)!>11@!2.!>11@!01,1*0$*4!.*!>#'2!5.+!'-1!>.-@$*4!.*!'*0!$3!01'0&$*1%!'-1!
',,-.'8#$*4;!!T1!>$&&!)112!>11@&5!$*0$/$0+'&&5!.-!$*!'!4-.+,!01,1*0$*4!.*!5.+-!,-.0182!3.-!hYW!
>11@!'%!>1&&!'%!2.!'*%>1-!'*5!A+1%2$.*%!5.+!) '5!#'/1;!!<!,-131-!2.!) 112!.*! [ .*0'5%;!!?&1'%1!
8.) 1!%11!) 1!2#1!3$-%2!>11@!.3!8&'\%1\!2.!'--'*41!'!2\\$) 1!2.!) 112:!!<3!5.+!*110!2.!-1\\8#10+&1!.-!
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 $\begin{array}{l} U.+! > \$\&\&! (1!-1A+\$-10!2.!4\$/1!!!2'\&@!\$^*!N181) (1-!^*0! ['5!.*!5.+-!\#.*.-\%!, -.0182;!!''\#1!0'21\%!3.-!2\#1!2'\&@\%! > \$\&\&! (1!, .\%210!.*!2\#1!91+-.\%8\$1*81! > 1 (\%21! G#22, \nsigma177 >>>; (.>0.\sigma^*;10+7*1+-.\sigma^*1811*81!3+10) 1 \nsigma^* \nsig$

+%.%*4#<-A'*#

U.+!> &&!(1!-1A+\$-10!2.!>-\$21!'*!#.*.-\%!, ',1-!3.-!5.+-!#.*.-\%!, -.0182;!!P='), &1\%!.3!8.), &1210! #.*.-%!,-.0182%!8'*!(1!3.+*0!.*!2#1!&\$(-'-5!>1(%\$21! G#22, %1770\$4\$2'&8.)) .*%;(.>0.\$*;10+7#.*.-%,-.0182%7H;!!U.+!%#.+&0!-1'0!%.) 1!.3!2#1!8.), &1210! #.*.-%!,-.0182%!\$*!91+-.%8\$1*81!2.!412!'*!\$01'!.3!>#'2!\$%!1=,18210!3.-!5.+-!#.*.-%!,',1-:!!U.+! > \$&&!(1!-1A+\$-10!2.!2+-*!\$*!'!0-'32!.3!5.+-!#.*.-%!,',1-!\$*!2#1!3'&&!%1)1%21-!'*0!'!3\$*'&!,',1-!\$*!2#1! %,-\$*4!%1) 1%21-:!!<*!2#1!3'&&!%1) 1%21-!5.+!'-1!1=,18210!2.!#'/1!'!>1&&DO1/1&.,10!&\$21-'2+-1!-1/\$1>! '*0!\$*2-.0+82\$.*6!) 12#.0%6!'*0!,-1&\$) \$*'-5!-1%+&2%!'*0!0\$%8+%%\$.*;!!<*!2#1!%,-\$*4!%1) 1%21-!5.+! '-1!1=, 18210!2.!#'/1!-1/\$%10!5.+-!\$*2-.0+82\$.*!'*0!3\$*'&\$R10!5.+-!) 12#.0%6!-1%+&2%6!'*0! 0\$\%8+\%\$.*:!!<*!'00\$\2\$.*!2.!5.+-!&'(!0+2\\$1\\6!5.+!\\#.+\&0!(1!-1'0\\$*4!,',1-\\!-1\\1/'*2!2.!5.+-!,-.0182! '*0!>.-@\$*4!.*!5.+-!, ',1-!2#-.+4#.+2!2#1!%+))1-!'*07.-!%1)1%21-;!!?&1'%1!3.&&.>!01'0&\$*1%! 3-.) !2#1!91+-.%8\$1*81!,-.4-') !6#22,%177>>>;(.>0.\$*;10+7*1+-.%8\$1*817-1A+\$-1)1*2%7#.*.-%D\$*01,;#2)&H!'*0!2#1!&\$(-'-5!G#22,%I77(.>0.\$*;&\$(4+\$01%;8.)7#.*.-%H;!!?&1'%1!-1'0!'&&!1)'\$&%!'*0! $3.\&\&.>!'\&\&!\&\S(-'-5!4+\$01\&\$*1\%!3.-!3.-)'22\$*4!G\%11!:1\$4\#i\%!,',1-!3.-!'*!1='),\&1H;!!<!'\&\%.!-18.))1*0!$ +%\$*4!P*09.21!.-!'*.2#1-!8\$2'2\$.*!)'*'41)1*2!%.32>'-1!3.-!8\$2\$*4!,',1-%;!!"#1!&\$(-'-5!#'%!+%13+&! \$*3.-)'2\$.*!.*!8\$2'2\$.*!)'*'41)1*2!2..&%!G#22,%I77(.>0.\$*;&\$(4+\$01%;8.)78\$2'2\$.*)'*'41)1*2H;!! <*!.-01-!3.-!) 1!2.!,-./\$01!3110('8@6!.&1'%1!1) '\$&!) 1!5.+-!,',1-!'%!'!:0.8=!%.!<!8'*!\$*%1-2!</p> 8.)) 1*2%;!!<!2-5!2.!,-./\$01!3110('8@!>\$2#\$*!d!>11@0'5%!.3!-181\$,2!.3!'*!#.*.-%!,',1-!%.!5.+! #'/1!2\$) 1!2.!-1/\$%1:!!! U.+!> \$&&! (1!4-'010!.*!5.+-!#.*.-%!.-.0182!1'8#!%1) 1%21-!('%10!.*!2#1!2\$) 1!'*0!133.-26! +*01-%2'*0\$*4!'*0!1*4'41) 1*2!>\$2#!2#1!,-.01826!2#1!,-1%1*2'2\$.*6!'*0!,',1-;!

 $\begin{array}{l} U.+-!\%+) \) \ 1-!31\&\&.>\%\#\$, !\$*8\&+O1\%! '!\%2\$, 1*O! '*O!\%+) \) \ 1-!\#.+\%\$*4!.*!8' \) \ ,+\%;!!<3!5.+!'-1!3+*010! \\ (5!'*!9<J!4-'*2!5.+!>\&\&!\#'/1!2.!3\&\&!.+2!'*O!\%+() \&2!2\$) \ 1\%\#112\%!\$*! \ T.-@0'5!3.-!' \ , , -./'\&!1/1-5! \\ 2>.!>11@\%;!!U.+!>\&\&!\#'/1!2.!' \ ,\&5!3.-!\%+) \) \ 1-!\#.+\%\$*4!'*O!\$*21-\$) \ !\#.+\%\$*4!\$3!5.+!*110!2.!\%2'5! \\ .*!8' \) \ ,+\%! \ (13.-1!.-!'321-!5.+-!31\&\&.>\%\#\$, !2\#-.+4\#!2\#1!S 33\$81!.3!P/1*2\%!'*O!E+) \) \ 1-! \\ ?-.4-' \) \ \$*4!G\#22,\%177>>>; \ (.>0.\$*;10+71/1*2\%7\%+) \) \ 1-D,-.4-' \) \%7\#.+\%*4;\#2 \) \&H;!!<!,-131-!'&\&! \\ \%2+O1*2\%!2.!>.-@!2#1!\%' \) \ 1!X!>11@\(6!a+*1Da+&56!>\#8\#!>1!>&\&\&!8..-O\(**21!.*81!31\&\&.>\%\#8, \%!'-1! \\ '>'-O10;!!U.+-!\%+) \) \ 1-!31\&\&.>\%\#8, !-1A+\$-1\(!2\#'2!5.+!>.-@!heW!\#.+-\%!, 1-!>11@;!! \ T \ 1!>&\&\&!\#'/1! \\ >11@\(&5!) \ 112\$*4\%70.+-*'&!8\&+(\%!>\#1-1!5.+!>&&&!\%#'-1!>\#'2!5.+!(11*!>.-@\(**4!.*6!412!\$*,+2!.*!'*5! \\ \#+-O&1\%!5.+!'-1!3' \(**4!-1\%1'-1!5.+-!,&'*\%13.-!3+2+-110\$-182\$.*\%!\$*15.+-!-1\%1'-8\#;!! \ T \ 1!>&&&!'\&.! \\ -1'O!'*O!O\(**0!0\%8+\%!,',1-\%!-1&1/'*2!2.!5.+-!-1\%1'-8\#!,-.0182!'*O!,-'82$81!4\(**4!-1\%1'-8\#!,-.1\%1'-8\#!,-.1\%1*2'2\(**2.*\%1!!<*1.>\%2\(**4.*\%1!-1\%1'-8\).!.\(**4.*\%1!-1\%1'-8\).!.\(**4.*\%1!-1\%1'-8\).!.\(**4.*\%1!-1\%1'-8\).!.\(**4.*\%1!-1\%1'-8\).!.\(**4.*\%1!-1\%1'-8\).!.\(**4.*\%1!-1\%1'-8\).!.\(**4.*\%1!-1\%1'-8\).!.\(**4.*\%1!-1\%1'-8\).!.\(**4.*\%1!-1\%1'-8\)...\(**4.*\%1$

 $\begin{array}{l} 0'5!.3!5.+-!\%+) \) \ 1-!-1\%1'-8\#!2.!'--'*41!'!2\$) \ 1!2.! \) \ 112;!!<*!'00\$2\$.*!2.!5.+-!-1\%1'-8\#! \\ -1\%,.*\%\$(\$\&\$2\$1\%!<!'\&\%.!1=,182!5.+!2.!,'-2\$\$,'21!\$*!'00\$2\$.*'\&!-1\$1'-8\$!'82\$/\$2\$1\$\$*8\&+0\$*4!2\$1! \\ >1\&8.) \ 1!\%1\%\$.*!3.-!\%+) \) \ 1-!-1\%1'-8\#!\%2+01*2\%6!2-'\$*\$*46!'*0!0\$\%8+\%\$*4!5.+-!-1\%1'-8\$!.2\$1.'\$1'-8\$!.2\$1-!\%+) \) \ 1-!(\$.\&.4\$8'\&!-1\%1'-8\$!!31\&\&.>\$\$$,'\%2+01*2\%;!!U.+!>\$\&\&!*.2!(1!-1A+\$-10!2.!0.!2\$1!\&'(!\%'3125!2-'\$*\$*4!'\%!\$2!\$\!*.2!*181\%'-5!3.-!.+-!-1\%1'-8\$;!!U.+!>\$\&\$\$\$!\$2\$\!*.2\$\$

=::636%.--297*%).:#5*-6.6.7#F%*#B':'*-&&"#B).:':#\$'4'-*2?#

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"#'*@!5.+!2.!2#1!C&5!:'(6!M.&+)($'!^*$/1-%$25!'*O!2#1!M#-'%2$&!:'(6!^*$/1-%$25!.3!M'&$3.-*$'6!</-/$*1!3.-!2#1!1='),&1!&'(!)'*+'&%;!
!
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