邢◀唷?>└? -□└└└┌? ♫└☆└◀└┘└!!└¶└€

n 痫 $L哞塵哄輧辟g1? 塒NG IHDRh2 囆n gAMA眻唱籀┌SPLTE c刻Jk()JZZ{孥s?
Zk BZRk{Jcs)BR)Rk!Jc Jk Bcc{孽s濝ZkBc{!9J!BZZ{擱s忑k?Zs1Rk)Jc 9R Bc 1J1Z()Rs!Jk 9Z Bkk剮Jc()BZ !9c{擻s孥k濝Zs9RkJk嬸c?Jc9Z{1Rs!9R)Jk!Bc 1J!Js 9Z)B Bk 1R 9c)J1R()Js!
Bk 9c 1Z 9kZs擱k忑c?BZBZ{9Rs1Jk)Bc!9Z 1R !9)J9Jc)Bk{擣c?9R9R(!1J1Js)Bk 1Z)R!9ccs擱c鬲Z{BRs9Jk1Bc)9Z!1R)J !B9Js1Bk)9c!1Z)R !J!)B19Z!)J 9!)R B ?V pHYs 逸` !IDATx測X鴅獼→?濕?咬波E ?Y E-攍?Y5 答└?姆I炎?ws?韟?)5jb 削 锼b舯繁??淼瓆刍h=05t鹧罾▽#抉泽涣u鸬罍捆└藉枏??Z嶒 I锌`l7.听Go?`X?掏{徵=.隹G喘?鞫庂倦!!绣?鸽羥??鍊I絢淢吣b d ??? ?匹n.胠苡J楞 髦?┼?
D坞xt?眹└"描7}蚯媚B鋘n诳?P梓?,氓蛆m %6墒偏嬉R仳郦7 尧缥3'崿wP廃←┼-/\倮?1锗x棉↑\問埒7?阚└℃Y€妩Q 点杌0??悢?◘ 気6 樓R匐邑←v{ ? 犊瓶妯泯X剜 B U?&?三⌊弶$欤!一●-M q硷 p詨???>瘡W悍#┼靫gB(苣 ¯¯ L;j4U??D\YY?嘘?NWN迩?]w20.|G哂 鵬?u崹i?腦涧咂\?橍L97緣腸W|r攭JG hP 怵?L数 ┐=1砬↔ ?N ?P盎鴮? |吻忌!!樫|漂? eT ?嫻蘑?0脑骰铸俄?鯔>t愢?O唬4U惩筌橦c 4噜K橉*Vf昂*筮tW鐵娟 焲●鎔└t r v??樌←玷{'髱赘← ;?鵹<┼B 度)惡€霖糰涿KNo撿橏>Q3 ?擯O? 錆?2a<熁琰?D&qj 9 ?劢偷`恆洀A!v??喇d? ??O?埽蹭rc梃Y瑞L|认圆?搰$Gm?sq*$嗒亭?Tf wn o ┑?騹既{▼?湖?D'F圃謯└〃?を螟<▲瓩榨 .好z纣HE?嫕n?- ┼d YI? C?>Xc 59芳润D堦鍼Kz礎W?┤ゐ 揉?掷诀?▼蹕襺"q?Z壺oVll祆x 伽?H?对H}c宜簑緇*└馱瑗v遒趋F割中└Z蟴?0?盖锫? :午_劉?A?鹵C {e 襄`瑟M]*酹1_坍挬6 疣/爽窢zR
弭?m挒}猻蘩◘酞粕z8鷅!A=2 背┘苆f鰥横O1匿篾} ?v瑟H?廝详 R贱p腰?? /?tY ◀S ?B鷁?p[7 G?IEND庖`偁F ?篦 $薯 ??叩 >蓁 ??叩 >蔞 ??叩 _曹 蕈 焦?▼e?烿 餈 O瞈 宵亏?/??豌_ 聵疡
萧亏??€赕?烿匡? 5? 簖7 酷F?? 熼匡? 5? 簖7 酷F?d焚 ?網??? 簖? 酷F?冂 熼 飼 5?唧?淇酝?蝟 燏_穡P 蓖 ?誉K?j ?跨??聩@>??O?鳴?劐 熨 襁穡P 彼怜 ?聩@>??泠?↔ 5 >??\ 憧酢?劁
隘?ぃ?锟 →€ 鷅?鎛鬰5??\ 吟5??\ 吟5 ^?O7?黩弟O嚯 ?繘j ???黥穴 ?┤?黥穴●?莠?哂F?`_ s M 唆? 炸▼黥穴h aO q M 唆? 灑▼黥穴h/負肤? M €啹2 周 咧 鈔}? ? o瘢^鈔 g?=`?稣科
峡唆裹饣鰳 凯?k? 禅}e 凯?k? 禅=e 凯?k? 禅?榲 o瘢^鈔 g[鎬 [黨赘h 袞敵 咧 →5? 鯣郡熊蹩荔{唆裹o 鐵?k? 祀o羁 o瘢^鈔 g[u 镢□??└?埯?□-黨赘●鯣 髅 科媽?俟矿?遲黨赘●鯣 ?菑 痘
!!?誉x 闱黨活┌鼾g 铡●鯨楛?鋅●鯨楛鵑鵋↑ fY 洗 ?p ?焗 *┐?f?洗 ?q??跨? €缚俣 箜| @\?硎跨? €?f?洗 魍┌p ?焗匡?猃溆 >??|名6晓}|ò\?硎 缵/ ?名:晓}?綴蜚?超 缵? ?名6晓}|?嚼@┌謁┘?長
F? J(?€ (?€ (?€ (┌h 詻?€ eT鲕佬?€ (?L €)P @ P @ 4憚?痺鲕楮┼P @ P @ P @聘|¶┌F/??\柳?
P @ P @ P @ P @ P @ P @ P @ P @ P @ P @ P @ P @ P @ P @ P @ P @ P @ P @ P @ P @ P @ P @ P @ P @ P @ P @ P @ P @ P @ P @ P @ P @ P @ P @ R?€ `¶P H ??€ J%聆?
0 ? /P ?€ (?€ (?竺┐Z?品7齟_鎔 借┌h?€ (?€ (?€ (?€ (?€ (?€ (?€ (?€ (?€ (?€ (?€ (?€ (?€ (?€ (?€ (?€ (?€ (?€ (?€ (

8iV　鼾／P?　道虐Vo ?瘸蔓P暲鍍?？祝U絃怒Ｓ疾\?+G拇鳴(箸蝠?蛮夜?冻仝°ｺ+f?｣|疡　芟W ?f?蔚褥黄V?P?蔚褥黄V?F?蔚褥黄U狗蔗!?r　"#　?r嘮嘿?　"栎T◀\??ｺm汳&W??諂N　RY漆?腔4諄嘱漾?=；蔗aK騷護敝鏑I鰲[鮈魏调E誊c??蔕?；(鰻→夕訇酮啸→說褒R　汪繡O　越？？ 惟?A??　　　

[illegible]

2 =?凿傿OM?@(　　R跃`!!_?zS??　?呱)?覛 V堇▲T輔n　=ɤ4切魁)□(?P　覣?€(蔷)€b€ b?0 ? ` R鶨P 甫┌H €`℞?P 娱|ㄅ　@ ?? 鶨€ 偕ㄏ羌範ㄅ?鄰●j6?@ 咰0　 ??? R?H €　斃(烟@氓 b　　P LAHbq襦ㄋ_?v?€ JLg　→蜈●緘@ 鯛Br?聊肉h　`啣90 貌鶨狂3憐妓gV3鄰 ㄋ鶨€ 鶨 N　j@:城@|℞?gi理@.鎚??丝?舊鶨R?P　幣 \?長!??K唾o岭轻棉鶨AOR胰???A碃?-E　(　陪-ㄋ襦@ &h i€g €A@ h?€ 駷!?P ?? 8 ?@ 鈉??迺€Z　鞞|¶€(檗?N ?€`?€ %0　幣 ??$ㄌ?`┌€) g ??鶨?&@?▲(燈€ €?┌@|0 鰻!4€3@　?@ ? 8鞞 澀?鄒┌ 蝯R s@ q迟┌傳┌?┌H灤!Ø ┼-?個<锪瑒L鈵S牟)+E麌┌麌渠:9鱸璗>牽 c姻┌?竝|鐃€H 趶 ┌徦l ┌?/a@ I扶¶ 3??y鈦□ ┘d`? 鑕?o鳩|q瑃ka[i檀o蝮┌驱?褛1}　D'澌烃@ 灏y岍浚┐?丐€c h　狛¶1! 4 廠:P:g　c 俏`|?¶▲8?栗齡1竝`(┌h ?? !藁€ 輝燵镇 浚!h 3袁|●:謤竝 4?s@锢□x鎮?P!s钎|?€ A鬆□:.□ ┘苒┌唾襦鶨?栗!8??攝┌?瀲y4欒p 4c獃!　蠟┌h?R鑰>澦┌?　? q篆<›鞘x顯:=?&1?　(????sHb`　想@ 9?:　　 轻@€鶨┌?3?　訣?(鯽`鶨€L?€ 浚　P 蛋崎兰孜 ??蘗甫t烟@|ㄏzR P!9 Q愧>個ㄌ)焗>城L ?　罐訓@s?　|#j2`　 耄S`蛾?!?!¶€ZC篱焜QL ?襦!!?　6丐\?:於?苑鶨|€ 刂?　 ?? 开胳●℗襦`s>:該忘K稷 4|¶?韓#?|i 柝:W鯛?爐?嫁?房?　聰bGC来4€N 锢 €R?/?A?鶨?€1?€ ┌|←|℞┌¶ ~ y夏H 炬拄o 踏 2　詹煸#x　躐?f座□　僵"啸~龄R ?牲??橛/膻┌€ ?S　`攥.(十欑bㄅ阅?0)€`R　T鈴A锢 €)鶨 b€ (┌G ?p(??`　 4繼撰A妓~rh?€　　 izㄨ阜罕q淏?2　茜唐絹峒t?(锢 冱€:P　q襦ㄋ聍┌€ 駷`　L?　蜚 2wb€　 殯N篋岫復淇?　m8　冷??i　 k瑟?蔓莸攥T (#???坂┌窑})?R　/J`　镠ㄋ 兆芦 蒌l▼蔭 6锢阙 崁ㄋ+Nq歸玩諗嫉?┌q@頌?¶ Wp 1　?m阋¶ 9?`4 _　ZA　┌蹙9d`l _十　`l?悅|&2h　q)€檳?迟ㄌb€　 齋1　迟!!8?　? 89?嗯9鶨●JA謹?S　P c犀1玄鈉勘z?香@ =)抽:P　冠€J@s　 ?怪　I　¶ ?q蹙[□>u鯛」蟈C ?J`　? Px顯ㄌ襦@ @|?¶€ 6?@ 0 @ P　 鶨|→?(┌h?€ ┌P h　澈z寮zt! b謎<搽;穩爪9籀>嘐@倫●襦 ,┌L ?悉@ `↑簸┌籀h　?瀆P　且€0覩k腺oK嘍 ?鞴鈉檜-{→c | 鄰€\x媚3]?蜣S ?蠶s庐▲G??瑃?(?塙-???FlP　s@　(槊-L▽C艕&揭低-I狪嵋粑|7畎M縺`?菰?u賦3€@疎┌@ ¶□(燈竝?┌€ >P P　 ??n(韓●-)€R4`zP　@　P B(qL ?P ?)b€ `℞?€ :S?蒴@|¶P　@ ?P ?@　 焗 ㄌ滿┌€ ?┘ -¶P　→嗟*u鄙　jM?1敵烟H　 ? ? 9 ?zP　c? 漾€98　觉b h h锢|¶┌蝯~榕H A ч α?　(?€ b　 €(绲%~?h?€ `↑?襦 (?€ (??恐待竝鈹?勃?灼◀嘱[??聽A??$鴉竝篆$且8[鶨KP悲a鈣~R聞?B　G?\#)??　 伐]造胥?苺把　溷鹋藥埃 请@Y?閘q*E　璉$忖鴉?]唄 2　I琨(5)鹼!禁2　#?蝾鎮Oq~竝~?榊x]琭>$篠T紀檻g麼s壬└!⑺　漸　臟　f源?!n犄'!?9　9 躓]幡屏嗡o陬岱璃|?玳揜+2　$?@ 鶨　→.;1?辛洞掣>阋6嫈?1蒟?|-穉?0)?　+$_　柘崎綁鎏\'　倘/璞L吊禡鎗n/　走走●　0剉?婉　_I彳 梏侃x?蹴|滤嘻f€)?D　疔??K槊砾s??`t　(S??　欄└?浚窠Z`　hbl€ 蹲)?@|0 乇锟郫ㄋ瀷{P　@ 1 !　?P(鈥ㄌ?崴;(锢□=:P　鲥┌€　鲥|鞞 H ?iv鲥┌4僵€　　 鄰|¶　6?u鈥鐓C　€z€□　^?●趑9?燠x剌?轸¶?>))骏1　@ %　€;P　{P0鋅?U?€(└氿!　奮< 螳匪cS`鑫?鎖　@ @|¶P　}) {P　行┌竝蹊└??襦!字€　濺┌h　:P　@　鄰　@ @*Z骓4{肄 ┬　, VX凛扶€?t鈥?鋨¶?|P　@　 8?8鰻€T?　Ph(　@?　鶨┌(堃-7锢 鐓G扬　q痟??襪蕤李!px謹z予●M辜ㄩ轡穩o/酮cI?%瀣牛T\　+c冂　v　鋟c跷€u伞 ?蹠ㄌYJ:(　:s?　u?　c　樓N=?紈`ㄑ　鐘臘\x筦舟?頂穩竣9W　臀`訊}ㄌ嚐魴J@-0 ?　銑`聽!?~蒟9　?? 歎!?-稟€　鉴　@□饋蕤　鼇[uPx鞞|0　　H　c祁-??□^?┌?鯛}h　zP　@　P　@　% JZN鵂|?€ 5 (锢 趑!?`-¶P 鞞 覘>緘¶P H € =?　 詮1蹠|檀?€ 1 !　?P(鈥ㄌ?襦`s>:該忘K稷 4|¶?韓#?|i 柝:W鯛?爐?嫁?房?　聰bGC来4€N 锢 €R?/?A?鶨?€1?€ ┌|←|℞┌¶ ~ y夏H 炬拄o 踏 2　詹煸#x　躐?f座□　僵"啸~龄R ?牲??橛/膻┌€ ?S　`攥.(十欑bㄅ阅?0)€`R　T鈴A锢 €)鶨 b€ (┌G ?p(??`　 4繼撰A妓~rh?€　　 izㄨ阜罕q淏?2　茜唐絹峒t?(锢 冱€:P　q襦ㄋ聍┌€ 駷`　L?　蜚 2wb€　 殯N篋岫復淇?　m8　冷??i　 k瑟?蔓莸攥T (#???坂┌窑})?R　/J`　镠ㄋ 兆芦 蒌l▼蔭 6锢阙 崁ㄋ+Nq歸玩諗嫉?┌q@頌?¶ Wp 1　?m阋¶ 9?`4 _　ZA　┌蹙9d`l _十　`l?悅|&2h　q)€檳?迟ㄌb€　 齋1　迟!!8?　? 89?嗯9鶨●JA謹?S　P c犀1玄鈉勘z?香@ =)抽:P　冠€J@s　 ?怪　I　¶ ?q蹙[□>u鯛」蟈C ?J`　? Px顯ㄌ襦@ @|?¶€ 6?@ 0 @ P　 鶨|→?(┌h?€ ┌P h　澈z寮zt! b謎<搽;穩爪9籀>嘐@倫●襦 ,┌L ?悉@ `↑簸┌籀h　?瀆P　且€0覩k腺oK嘍 ?鞴鈉檜-{→c | 鄰€\x媚3]?蜣S ?蠶s庐▲G??瑃?(?塙-???FlP　s@　(槊-L▽C艕&揭低-I狪嵋粑|7畎M縺`?菰?u賦3€@疎┌@ ¶□(燈竝?┌€ >P P　 ??n(韓●-)€R4`zP　@　P B(qL ?P ?)b€ `℞?€ :S?蒴@|¶P　@ ?P ?@　 焗 ㄌ滿┌€ ?┘ -¶P　→嗟*u鄙　jM?1敵烟H　 ? ? 9 ?zP　c? 漾€98　觉b h h锢|¶┌蝯~榕H A ч α?　(?€ b　 €(绲%~?h?€ `↑?襦 (?€ (??恐待竝鈹?勃?灼◀嘱[??聽A??$鴉竝篆$且8[鶨KP悲a鈣~R聞?B　G?\#)??　 伐]造胥?苺把　溷鹋藥埃 请@Y?閘q*E　璉$忖鴉?]唄 2　I琨(5)鹼!禁2　#?蝾鎮Oq~竝~?榊x]琭>$篠T紀檻g麼s壬└!⑺　漸　臟　f源?!n犄'!?9　9 躓]幡屏嗡o陬岱璃|?玳揜+2　$?@ 鶨　→.;1?辛洞掣>阋6嫈?1蒟?|-穉?0)?　+$_　柘崎綁鎏\'　倘/璞L吊禡鎗n/　走走●　0剉?婉　_I彳 梏侃x?蹴|滤嘻f€)?D　疔??K槊砾s??`t　(S??　欄└?浚窠Z`　hbl€ 蹲)?@|0 乇锟郫ㄋ瀷{P　@

? ?h The static deflection of the product on the linear cushion is: so Equation 13.11 may also be written as: 13. 12 The maximum force exerted upward by the cushion against the product occurs when : 13.13 The maximum acceleration (or deceleration) experienced by the product, Gm, may be found from the relationship: ?>i @ (? h ? ? ? + ? ?? 13.14 13.15 where Gm is unitless, but is understood to be in units of 1 g. 13.16 Gm is proportional to the square root of the drop height: This means that if we double the drop height, the magnitude of the shock is not doubled, but rather increased by a factor of (about 1.4). Equation 13.15 may be rearranged to produce an expression for : 13.17 ??

M 5 w ?BM ? ? ? ? 1 ? ??Equation 13.11 may also be rearranged to produce an equivalent expression: 13.18 13.19 giving us an expression for the maximum dynamic compression as a function of the maximum acceleration and the drop height. Conclusions: 1. is related to the drop height, the springiness of the cushion and the weight of the product. 2. The stiffer the spring or cushion, the larger the value for. 3. The higher the drop height, the larger the value for(). 4. The heavier the product, the smaller the value of as long as the spring or cushion is working. ?j? ? G 9 ?

? ? ? ? 9 ? ? Shock Duration ? (? ? ??We may approximate the displacement of the product on the cushion,, at any time during the impact with the function: 13.20 where 13.21 f2 - the natural frequency of the product (M2) on the cushion (k2). ?t?)

? ? ? : ? ?5Figure 13.7 Shock duration and maximum displacement ? 66 ? 5 ? ; ? ??T2 - The period of the free vibration of the product on the cushion: 13.22 where - the time length or duration of the shock. For any shock of known period , we may calculate the equivalent shock frequency: 13.23 the shock duration: 13.24 13.25 ?:? ? ? ? ? ? ? C ? ?-Shock Amplification and the Critical Element ? . . ?

??Define: Ge - the maximum acceleration experienced by the critical element, resulting from a shock(Gm and), as shown in Figure 13.9. Am - an amplification factor, analogous to vibration magnification relating the input and output shock levels: 13.26 Ge = Am Gm 13.27?? Z !

?N] ? D ? ? Figure 13.9 Shock transmission?

? ? E ? ??During the impact, the amplification factor is given by the expression: 13.28 where N - an integer f2 - the equivalent shock frequency f1 - the natural frequency of the critical element Just after impact, the amplification factor is: 13.29?? E # ? ? ?

? ? F ? ?6 The largest value of Am for Equation 13.27 depends on the relationship of and : 1. If (Equation 13.29) 2. If (Equation 13.28) 3.Notice that as the ratio becomes large, the value for Am approaches 1, reflecting the "direct" transfer of the shock to a stiff element. 4.For small values of the frequency ratio: ?

$Lesson 13 Mechanical Shock Theory TOADn 1 boxes 1 TOAD 1 9AD Microsoft PowerPoint1
Root Entry @Pictures Current User SummaryInformation(PowerPoint Document(DocumentSummaryInformation8
Equation.30? Microsoft 1Q _ 3.0
?DTimesa ?DGaramond ?DWingdings 0?DTimes New Roman8? P?DFranklin Gothic Medium8? ?DVerdana Gothic Medium8?
___PPT10?

Lesson 13 Mechanical Shock Theory

Introduction

Throughout the distribution system, packages are manhandled and mishandled in various ways: dropped, thrown, kicked and otherwise roughly abused; fall from conveyors or forklifts and crash to the floor; subjected to a variety of vehicle impacts; trucks starting, stopping, hitting chuckholes and railroad crossings, railcar humping, jolting and other moderately violent actions; suffers an impact with another object floor, truck bed, pallet, bulkhead or another package. A mechanical shock occurs when an object's position, velocity or acceleration suddenly changes. Such a shock may be characterized by a rapid increase in acceleration followed by a rapid decrease over a very short period of time. Figure 13.1: the acceleration versus time plot for most shocks

Figure 13.1 Representation of mechanical shock

A package shock may typically be 20 milliseconds (0.020 seconds) long and have a magnitude or "height" of 150 g's. need to know both the magnitude of the acceleration and the duration of the shock.

The Free Falling Package the length of time it takes a package to fall from a drop height, h the

downward velocity at which it will be traveling a moment before impact; , the impact velocity: As is shown in Figure 13.2. A package will rebound a little or a lot depending on the nature of the package and the surface it hits. ? SD S Sd S S S e ?? a a Ba a sa a a ? h ? ? ? Figure 13.2 A falling package?$ ` b ?(? ? ?V coefficient of restitution, e, describes the rebound velocity as a function of the impact velocity 13.1 total velocity change: 13.2 13.3 Because 0 1(typical values falling in the 0.3 to 0.5 range): 13.4 velocity change is also numerically equal to the area beneath the shock pulse as shown in Figure 13.3.?ZW c g g 9 g ?(U ? ? ? ? ?5Figure 13.3 The relationship among shock parameters ? 66b ? 5 ? ? ? ? ?f Package damage is related to the three factors involved in mechanical shock: Peak Acceleration Duration Velocity Change Mechanical Shock Theory Shown in Figure 13.4, the product-package system consists of four basic components: the outer container, the cushion, the product, and a critical element. shown in Figure 13.5: the product-package model: ?N 0 jc c c c g ?? c c ` ? f ? ? ?+Figure 13.4 A simple product-package system? ,,c ? + ? ? ? ? ?? M2 - the mass of the product M1- represents the mass of the critical element or CE M3 - represents the mass of the outer container kl - the linear spring constant of the sprint-mass system representing the critical element k2 - the linear spring constant of the cushion system Assumptions for simplicity: a. ignore the mass of the outer container and assume that it provides no spring action; b. the cushion has no mass or damping and suffers no permanent deflection from a shock; c. the product-package system impacts a perfectly rigid floor; d., the mass of the critical element is negligible compared to the mass of the product. In Figure 13.6, the impact of a product-package: ? I? I b c c c 7c c 1c c]c c ?c ?B I ? ? ?3Figure 13.6 The impact of a product-package system? 44c ? 3 ? ? ??At Point A, the product is ready to fall. The potential energy at this moment is: 13.5 where At Point C, the kinetic energy of the system is given by 13.6 13.7 which show that the kinetic energy at this moment is equal to the initial potential energy of the system. In the moments following the initial contact of the container with the impact surface, the amount of energy absorbed by the linear cushion is: 13.8?t? g g g g 3 g ? ? ? ? ? ! ? ??whereX2is the downward displacement of the product on the cushion. At Point D, the cushion has absorbed all of the system's kinetic energy 13.9 where maximum dynamic compression, dm= maximum value of x2. The maximum amount of energy absorbed by the cushion must equal the system's kinetic energy at impact: 13.10 for the maximum dynamic compression: 13.11?J? Mg g 6 g ? ? ? ? ? * ? ?h The static deflection of the product on the linear cushion is: so Equation 13.11 may also be written as: 13. 12 The maximum force exerted upward by the cushion against the product occurs when : 13.13 The maximum acceleration (or deceleration) experienced by the product, Gm, may be found from the relationship: ?Ji @ g g (g ? h ? ? ? + ? ?? 13.14 13.15 where Gm is unitless, but is understood to be in units of 1 g. 13.16 Gm is proportional to the square root of the drop height: This means that if we double the drop height, the magnitude of the shock is not doubled, but rather increased by a factor of (about 1.4). Equation 13.15 may be rearranged to produce an expression for : 13.17 ?? Mc g g 5g g g g w g c ?BM ? ? ? ? 1 ? ??Equation 13.11 may also be rearranged to produce an equivalent expression: 13.18 13.19 giving us an expression for the maximum dynamic compression as a function of the maximum acceleration and the drop height. Conclusions: 1. is related to the drop height, the springiness of the cushion and the weight of the product. 2. The stiffer the spring or cushion, the larger the value for. 3. The higher the drop height, the larger the value for(). 4. The heavier the product, the smaller the value of as long as the spring or cushion is working. ?€??g g g g 9 g b ? ? ? ? ? 9 ? ? Shock Duration ?(c (` ? ? ??We may approximate the displacement of the product on the cushion,, at any time during the impact with the function: 13.20 where 13.21 f2 - the natural frequency of the product (M2) on the cushion (k2). ?? c c c)c c c c c ? ? ? : ? ?5Figure 13.7 Shock duration and maximum displacement ? 66c ? 5 ? ; ? ??T2 - The period of the free vibration of the product on the cushion: 13.22 where - the time length or duration of the shock. For any shock of known period , we may calculate the equivalent shock frequency: 13.23 the shock duration: 13.24 13.25 ?F? g ?g c ? ? ? ? ? C ? ?-Shock Amplification and the Critical Element ? . .c ? ?? Define: Ge - the maximum acceleration experienced by the critical element, resulting from a shock(Gm and), as shown in Figure 13.9. Am - an amplification factor, analogous to vibration magnification relating the input and output shock levels: 13.26 Ge = Am Gm 13.27?? c c Z c c ! c c c c c c c c ?N] ? D ? ? Figure 13.9 Shock transmission? c ? ? E ? ??During the impact, the amplification factor is given by the expression: 13.28 where N - an integer f2 - the equivalent shock frequency fl - the natural frequency of the critical element Just after impact, the amplification factor is: 13.29?? E g g g g #g g g ? ? ? ? ? F ? ?6 The largest value of Am for Equation 13.27 depends on the relationship of and : 1. If (Equation 13.29) 2. If (Equation 13.28) 3.Notice that as the ratio becomes large, the value for Am approaches 1, reflecting the "direct" transfer of the shock to a stiff element. 4.For small values of the frequency ratio: ?7 g g hg R g g g g ? 6 ? ? ? ? ? € ?KO ? ?c ? ?q ? ?F { ?? q ?? ? ? ? |0e 0e l' . A ? ? ??

? ? ? ? ? €€€ ?73-2#"??`? ?| ??? ?? q ? ? c |0e 0e P b' ? A ? ? ? ? €€€ ?73-2#"??`? ?z ? ? ?? q ? ?? ? ?h? ? ? 33 ??? PPT10?i? t3? pg E+ D?'? ? =?@B? +r {P ? ? I s