

**SUMMER EXAMINATIONS 2019**

**EXAMINATION:**

**UNIT 1 Fundamentals of Packaging Technology and Packaging in the Supply Chain**

**COURSE:**

**CPD Diploma in Packaging Technology**

**DATE:**

**8th May 2019**

**10am to 12pm**

**EXAMINERS: Colm Munnelly, David Little**

**TIME ALLOWED: 2 hours**

**INSTRUCTIONS: Please answer four questions. All questions carry equal marks**

**PLEASE DO NOT TURN OVER THIS PAGE UNTIL YOU ARE INSTRUCTED TO DO SO**

**The use of programmable or text storing calculators, smart phones etc are expressly**

**forbidden. Please note that where a candidate answers more than the required number of questions, the examiner will mark all questions attempted and then select the highest scoring ones.**

**Unit 1** **Page 1 of 3**

**Question 1 (25 marks)**

1. **With regard to developing a new product and understanding how it would be stored and distributed, discuss how you would set about defining and designing packaging for the Warehouse and Distribution environment.**

**(20 marks)**

1. **List five (5) Hazards of Distribution.**

**(5 marks)**

**Question 2 (25 marks)**

1. **Why would you use Pallet Design Software? Briefly discuss TEN typical ADVANTAGES of such software to illustrate your answer**

**(10 X 1 mark)**

1. **Discuss FIVE factors that could compromise the compression strength of a case if not taken into consideration at the beginning of the design process**

**(5x2 marks)**

1. **Sketch and label the packaging design sequence you would consider when designing packaging for a plastic bottle of ketchup collated in cases using pallet design software. Why is it important to consider all of these elements at the design stage?**

**(5 marks)**

**Question 3 (25 marks)**

1. **What are the functions of packaging and discuss why they are important to Brand Owners, Packer/Fillers and End Users.**

**(15 marks)**

1. **Select two of the following packs and explain how the various levels of packaging perform the functions of packaging for their product. Focus on the top 3-4 functions.**

**Box of Cornflakes**

**Easter Egg**

**6 pack of bottled beer**

**Packet of biscuits**

**(Using these examples, you may state a specific product type, style or format, if required.)**

**(2 X 5 marks**

**Question 4 (25 marks)**

1. **Calculate the fragility factor, G for a cup dropped from a height of 800 mm that decelerates to 0 on impact in 0.002 seconds.**

**Note: v2 =u2 + 2as and v =u + a τ where:**

1. **final velocity (m/s)**
2. **initial velocity (m/s)**
3. **acceleration (m/s/s)**
4. **distance travelled (m) τ: time taken(s)**
5. **acceleration due to gravity (9.81m/s/s)**

**(12 marks)**

1. **What thickness of expanded polystyrene foam would be required to protect this cup, dropped from the same height, knowing that the cushion factor for EPS is 2.6**

**(3 marks)**

1. **What are the internal dimensions of a case required to pack this cup in EPS if the dimensions of the cup are 150 x 130 x 130 mm**

**(3 marks)**

1. **Packaged products sometimes get dropped from a height. Briefly discuss some of the assumptions made when designing packaging that may be dropped.**

**(7 marks)**

**Question 5 (25 marks)**

1. **Briefly discuss five ways in which packaging has supported the development of modern societies.**

**(10 marks)**

**b) Discuss what you understand by the term “an environmentally responsible pack”**

**(5 marks)**

**c)** **Using examples, describe what you would consider when designing such a pack**

**(4 marks)**

1. **What is a carbon footprint (2 marks) and briefly discuss the reasons why you would calculate it (4 marks)**

**(6 marks)**

**Unit 1** **Page 3 of 3**

**Question 1 (25 marks)**

1. **With regard to developing a new product and understanding how it would be stored and distributed, discuss how you would set about defining and designing packaging for the Warehouse and Distribution environment.**

**(20 marks)**

## Defining and Designing Packaging for Warehouse and Distribution:

Here's a step-by-step approach to defining and designing packaging for a new product, considering warehouse and distribution needs:

**1. Understand the Product:**

* **Fragility and Sensitivity:** Identify if the product is delicate, prone to breakage, or sensitive to temperature, moisture, or light.
* **Weight and Dimensions:** Measure and document the product's weight and dimensions. This will influence box size, stacking limitations, and potential handling needs.
* **Stackability:** Determine if the product can be safely stacked on top of each other without damage.

**2. Analyze the Distribution Channel:**

* **Transportation Modes:** Identify the transportation modes likely to be used (truck, train, ship, air). Each mode presents different vibration and handling challenges.
* **Storage Conditions:** Consider the storage environment at warehouses and distribution centers (temperature, humidity control).
* **Distribution Network Complexity:** Will the product go through multiple sorting and handling points before reaching the final customer?

**3. Define Packaging Requirements:**

* **Protection:** The primary function is to safeguard the product throughout the supply chain. Choose materials and designs that provide adequate protection against drops, impacts, vibrations, crushing, and environmental factors relevant to your product.
* **Stackability and Stability:** Packaging should allow for secure stacking on pallets or shelves to optimize warehouse space and minimize the risk of toppling or crushing.
* **Efficiency:** Consider the ease and speed of packing and unpacking the product. Opt for designs that minimize labor costs and handling time.
* **Sustainability:** Explore environmentally friendly packaging materials and designs whenever possible. Biodegradable or recyclable materials can contribute to a sustainable supply chain.

**4. Design and Testing:**

* **Develop Packaging Prototypes:** Create physical prototypes of your packaging design based on the defined requirements.
* **Drop Testing:** Simulate potential drops from various heights to assess the packaging's ability to protect the product.
* **Vibration Testing:** Expose the packaged product to controlled vibrations to evaluate its resilience during transportation.
* **Compression Testing:** Test the packaging's resistance to crushing forces that might occur during stacking or storage.

**5. Warehouse and Distribution Integration:**

* **Consult with Warehouse Experts:** Get feedback from warehouse personnel on the packaging's ease of handling, stacking efficiency, and compatibility with existing warehouse systems.
* **Labeling and Information:** Ensure clear and compliant labeling with relevant handling instructions, product information, and barcodes for efficient tracking throughout the supply chain.

**6. Cost Optimization:**

* **Material Selection:** Balance the cost of packaging materials with the required level of protection for your product. Explore cost-effective options that meet performance requirements.
* **Right-sizing:** Avoid using overly large boxes that waste space and increase transportation costs. Aim for a snug fit that minimizes void fill materials.

**7. Sustainability Considerations:**

* **Recyclable Materials:** Prioritize using recyclable cardboard, paper, or plastic materials whenever possible.
* **Minimal Void Fill:** Minimize the use of excessive packing peanuts or void fill materials. Explore air pillows or biodegradable alternatives.
* **Sustainable Sourcing:** Look for packaging materials made from recycled content or sustainably managed forests.

**By following these steps and considering all aspects of the warehouse and distribution environment, you can design packaging that effectively protects your product, optimizes warehouse handling, and contributes to a more sustainable supply chain.**

1. **List five (5) Hazards of Distribution.**

**(5 marks)**

1. **Physical Impact:** This is the most common hazard and encompasses various situations that can damage the product or packaging during transportation and handling. Examples include:  
   * **Drops, bumps, and jostling:** These can cause dents, tears, punctures, or complete box failure.
   * **Vibration:** Constant vibrations during transport can weaken packaging materials, leading to tears, loose seals, or product settling.
   * **Compression:** Stacking heavy boxes can crush fragile items or deform packaging, making it susceptible to further damage.
2. **Environmental Conditions:** Fluctuations in temperature, humidity, and exposure to sunlight can negatively impact both packaging and product integrity. This includes:  
   * **Temperature extremes:** Heat can warp plastics or cause cracks in some materials, while freezing temperatures can damage certain products like food or pharmaceuticals.
   * **Humidity:** High humidity can weaken cardboard boxes and promote mold growth on organic materials.
   * **Sunlight:** Direct sunlight can fade packaging colors and deteriorate some plastics.
3. **Stacking and Storage Practices:** Improper stacking or storage can contribute to packaging damage, such as:  
   * **Overstacking:** Exceeding the weight limit of lower boxes can lead to crushing.
   * **Inadequate Support:** Storing packages on uneven surfaces or without proper pallets can cause them to sag or warp.
   * **Long-term Storage:** Extended storage exposes packaging to environmental factors and potential rough handling during stock rotation, increasing the risk of wear and tear.
4. **Handling Practices:** Human error during handling can also contribute to damage, including:  
   * **Dropping Packages:** Accidental drops from shelves or delivery trucks can cause significant damage.
   * **Improper Lifting Techniques:** Incorrect lifting techniques can put stress on the packaging, leading to tears or rips.
   * **Lack of Training:** Inadequate training for warehouse staff or delivery personnel on proper handling procedures can increase the risk of damage.
5. **Theft and Pilferage:** While not directly impacting the packaging itself, theft can lead to product loss. This can be:  
   * **Weak Packaging:** Inadequate packaging can make products more vulnerable to tampering during transportation or storage.
   * **Unattended Deliveries:** Packages left unattended on doorsteps are more susceptible to theft, resulting in lost product and customer dissatisfaction.

**Question 2 (25 marks)**

1. **Why would you use Pallet Design Software? Briefly discuss TEN typical ADVANTAGES of such software to illustrate your answer**

**(10 X 1 mark)**

Pallet design software is used to optimize the layout and configuration of pallets for efficient storage, handling, and transportation of goods. The typical advantages of using pallet design software include:

1. \*\*Optimized Space Utilization\*\*: Software helps maximize the use of available space on pallets, reducing wasted space and improving storage efficiency.

2. \*\*Load Stability\*\*: Ensures that loads are stacked securely and evenly on pallets to prevent shifting or toppling during handling and transportation.

3. \*\*Weight Distribution\*\*: Helps distribute weight evenly across the pallet to prevent overloading and ensure safe handling.

4. \*\*Cost Efficiency\*\*: Reduces material and transportation costs by optimizing pallet configurations to minimize waste and maximize load capacity.

5. \*\*Time Savings\*\*: Speeds up the pallet design process, saving time and effort compared to manual calculations and trial-and-error methods.

6. \*\*Customization\*\*: Allows for customization of pallet designs to meet specific requirements, such as load capacity, dimensions, and stacking configurations.

7. \*\*Compatibility\*\*: Ensures that pallet designs are compatible with handling equipment, storage systems, and transportation vehicles.

8. \*\*Safety Compliance\*\*: Helps ensure that pallet designs meet safety standards and regulations to prevent accidents and injuries.

9. \*\*Environmental Impact\*\*: Enables the design of sustainable pallet solutions that reduce waste and environmental impact.

10. \*\*Visualization\*\*: Provides visual representations of pallet designs, allowing for better planning and decision-making in the packaging and logistics processes.

1. **Discuss FIVE factors that could compromise the compression strength of a case if not taken into consideration at the beginning of the design process**

**(5x2 marks)**

Here are five factors that could compromise the compression strength of a case if not considered during the design process:

1. **Material Selection:** The material itself plays a crucial role in compression strength.  
   * **Strength Properties:** Different materials have varying inherent compressive strengths. Cardboard grades, for example, are categorized based on their ability to withstand compression forces. Choosing a material with insufficient strength for the intended load can lead to case failure.
   * **Material Thickness:** The thickness of the material directly impacts its ability to resist compression. Thicker materials generally offer greater compression strength, but there's a balance to be struck with weight and cost considerations.
2. **Structural Design:** The overall design of the case significantly influences its ability to handle compression forces.  
   * **Panel Configuration:** The arrangement of panels in the case can affect its strength. Strategically placed panels and reinforcing elements can distribute compression forces more effectively.
   * **Folding and Joining Methods:** The way the case folds and seals can create weak points if not designed properly. Folds can act as stress concentrators, and weak adhesive bonds might not hold under significant compression.
3. **Stacking Patterns and Distribution Conditions:** Understanding how the cases will be stacked and handled throughout the supply chain is crucial.  
   * **Stack Weight:** The total weight of cases stacked on top of each other can exceed the compression strength of a single case. Designing for the anticipated stacking pattern ensures the bottom cases can handle the cumulative weight.
   * **Vibration and Impact:** Transportation can subject cases to vibrations and impacts that can weaken the case structure over time. Designing for these dynamic forces helps maintain compression strength throughout the distribution process.
4. **Environmental Factors:** Exposure to certain environmental conditions can affect the material properties and compromise compression strength.  
   * **Moisture:** High humidity can weaken cardboard and other paper-based materials, reducing their ability to resist compression.
   * **Temperature:** Extreme temperatures might affect the adhesive strength of joints or cause warping in some materials, impacting the case's overall integrity.
5. **Cost Optimization:** While achieving optimal compression strength is important, there's always a need to balance it with cost considerations.  
   * **Material Efficiency:** Overly thick or heavy materials might provide excessive strength but also increase costs. Optimizing material usage while maintaining sufficient compression strength is crucial.
   * **Production Considerations:** Manufacturing processes and assembly methods can impact final case strength. Designing for efficient production should not compromise the structural integrity of the case under compression.

By carefully considering these factors during the design process, manufacturers can create cases with robust compression strength that withstand the rigors of the supply chain while optimizing cost and production efficiency.

1. **Sketch and label the packaging design sequence you would consider when designing packaging for a plastic bottle of ketchup collated in cases using pallet design software. Why is it important to consider all of these elements at the design stage?**

**(5 marks)**

When designing packaging for a plastic bottle of ketchup collated in cases using pallet design software, the packaging design sequence would typically involve the following steps:

1. \*\*Product Analysis\*\*: Understand the dimensions, weight, and fragility of the plastic bottle of ketchup to determine the packaging requirements.

2. \*\*Case Design\*\*: Design the case structure to securely hold and protect the plastic bottles of ketchup during storage, handling, and transportation.

3. \*\*Palletization\*\*: Determine the optimal pallet layout to efficiently stack and secure the cases of plastic bottles for safe and stable transportation.

4. \*\*Stacking Configuration\*\*: Consider the stacking configuration of the cases on the pallet to ensure stability and weight distribution.

5. \*\*Pallet Design\*\*: Use pallet design software to optimize the pallet layout, taking into account weight distribution, load capacity, and stacking patterns.

It is important to consider all these elements at the design stage because:

- \*\*Efficiency\*\*: Optimizing the packaging design sequence ensures efficient use of space, materials, and resources, leading to cost savings and improved logistics.

- \*\*Product Protection\*\*: Proper packaging design helps protect the plastic bottles of ketchup from damage during handling and transportation, maintaining product quality and integrity.

- \*\*Safety\*\*: Considering all elements at the design stage ensures that the packaging is safe for handling, stacking, and transportation, reducing the risk of accidents or product damage.

- \*\*Supply Chain Optimization\*\*: By designing packaging that is compatible with pallet design software, the entire supply chain process can be streamlined, leading to smoother operations and reduced risks of damage or inefficiencies.

- \*\*Customer Satisfaction\*\*: Well-designed packaging that considers all elements from the beginning ensures that the product reaches the end consumer in optimal condition, enhancing customer satisfaction and brand reputation.

**Question 3 (25 marks)**

1. **What are the functions of packaging and discuss why they are important to Brand Owners, Packer/Fillers and End Users.**

**(15 marks)**

The functions of packaging are crucial for Brand Owners, Packer/Fillers, and End Users in the food industry. These functions play a vital role in ensuring product quality, safety, and market success. The key functions of packaging and their importance to each stakeholder are:

1. \*\*Containment and Protection\*\*: Packaging serves to contain and protect the product during storage, transportation, and handling. For Brand Owners, this function ensures that the product reaches the end user in optimal condition, maintaining brand reputation and customer satisfaction. Packer/Fillers benefit from the containment and protection of the product during production and distribution, ensuring product integrity. End Users rely on packaging to safeguard the product from damage and contamination, ensuring safety and quality.

2. \*\*Preservation\*\*: Packaging helps preserve the product by preventing chemical, biochemical, and microbiological spoilage. Brand Owners benefit from extended shelf life and reduced product waste, enhancing profitability. Packer/Fillers can maintain product freshness and quality through effective preservation. End Users receive products that are safe, fresh, and long-lasting, enhancing their overall experience.

3. \*\*Information\*\*: Packaging provides essential information about the product, including ingredients, usage instructions, and branding. Brand Owners use packaging to communicate brand identity, product features, and marketing messages. Packer/Fillers ensure regulatory compliance and consumer transparency through accurate product information. End Users rely on packaging for product details, nutritional information, and safety instructions, making informed purchasing decisions.

4. \*\*Convenience\*\*: Packaging offers convenience in handling, opening, and storage for both Brand Owners and End Users. Brand Owners can design packaging for efficient distribution and display, enhancing market visibility. Packer/Fillers benefit from packaging that streamlines production processes and logistics. End Users appreciate packaging that is easy to use, store, and dispose of, improving user experience.

5. \*\*Presentation and Brand Communication\*\*: Packaging design plays a crucial role in brand communication and product differentiation. Brand Owners use packaging to convey brand identity, values, and quality to consumers, influencing purchasing decisions. Packer/Fillers can leverage packaging design to enhance product visibility and market appeal. End Users are attracted to visually appealing packaging that reflects product quality and brand image, influencing their perception and loyalty.

In summary, the functions of packaging are essential for Brand Owners, Packer/Fillers, and End Users in the food industry. They ensure product quality, safety, and market success, contributing to brand reputation, consumer satisfaction, and overall business performance.

1. **Select two of the following packs and explain how the various levels of packaging perform the functions of packaging for their product. Focus on the top 3-4 functions.**

**Box of Cornflakes**

**Easter Egg**

**6 pack of bottled beer**

**Packet of biscuits**

**(Using these examples, you may state a specific product type, style or format, if required.)**

**(2 X 5 marks**

## 1. Box of Cornflakes and 3. 6-Pack of Bottled Beer: Packaging Functions

Let's focus on a **box of cornflakes** and a **6-pack of bottled beer** to explore how different packaging levels perform key functions:

**Product:**

* **Cornflakes:** Delicate cereal flakes susceptible to crushing and moisture absorption.
* **Bottled Beer:** Glass bottles containing pressurized liquid, requiring protection from breakage and damage.

**Functions and Packaging Levels:**

1. **Protection:**
   * **Cornflakes:**
     + **Primary Packaging:** Inner bag made of food-grade plastic or foil keeps cereal fresh, protects from moisture, and prevents crushing within the box.
     + **Secondary Packaging:** Cardboard box provides structural support, prevents crushing from stacking and external impacts, and offers some protection from light.
   * **Bottled Beer:**
     + **Primary Packaging:** Individual glass bottles are the primary containers for the beer, protecting the liquid from contamination and maintaining carbonation.
     + **Secondary Packaging:** Cardboard carrier with plastic rings or dividers holds the bottles together, preventing them from clinking and breaking during transport. The carrier might also offer some protection from light exposure.
2. **Containment:**
   * **Cornflakes:**
     + **Primary Packaging:** Inner bag directly contains the cereal flakes.
     + **Secondary Packaging:** Cardboard box provides a larger container for handling and storing multiple bags of cereal.
   * **Bottled Beer:**
     + **Primary Packaging:** Individual glass bottles are the primary containers for the specific serving size of beer.
     + **Secondary Packaging:** Cardboard carrier groups the bottles together for easier handling and transportation, preventing them from rolling around.
3. **Information and Marketing:**
   * **Cornflakes:**
     + **Primary Packaging:** May have limited information like brand logo and best-before date.
     + **Secondary Packaging:** Cardboard box provides a larger canvas for displaying branding, nutritional information, ingredients list, and marketing messages.
   * **Bottled Beer:**
     + **Primary Packaging:** Bottle labels display brand name, beer type, alcohol content, ingredients, and any marketing information specific to the beer variety.
     + **Secondary Packaging:** Carrier might have minimal branding information but can be used for promotional messages or point-of-sale displays.
4. **Convenience:**
   * **Cornflakes:**
     + **Primary Packaging:** Resealable plastic bag can offer some convenience for maintaining freshness after opening.
     + **Secondary Packaging:** Cardboard box with a pouring spout (depending on design) can facilitate easy dispensing of cereal.
   * **Bottled Beer:**
     + **Primary Packaging:** Glass bottles are typically resealable with a crown cap, allowing for unfinished beer to be stored.
     + **Secondary Packaging:** Cardboard carrier with a handle makes it easier to carry multiple bottles at once.

**Key Takeaways:**

Both packaging examples demonstrate how different levels work together to achieve various functions. Inner packaging offers primary protection and containment, while outer packaging provides additional structural support, information, and convenience features. The specific design choices for each level depend on the product's unique needs.

**Question 4 (25 marks)**

1. **Calculate the fragility factor, G for a cup dropped from a height of 800 mm that decelerates to 0 on impact in 0.002 seconds.**

**Note: v2 =u2 + 2as and v =u + a τ where:**

1. **final velocity (m/s)**
2. **initial velocity (m/s)**
3. **acceleration (m/s/s)**
4. **distance travelled (m) τ: time taken(s)**
5. **acceleration due to gravity (9.81m/s/s)**

**(12 marks)**

## Calculating Fragility Factor (G) for a Dropped Cup

We can calculate the fragility factor (G) using the following steps:

1. **Find the initial velocity (u) just before impact:**

We know the cup is dropped from a height (h) of 800 mm (0.8 meters). We can use the formula:

v² = u² + 2as

where:

* v = final velocity (m/s) = 0 (since the cup decelerates to 0 on impact)
* u = initial velocity (m/s) (what we need to solve for)
* a = acceleration due to gravity = 9.81 m/s²
* s = distance traveled (m) = h = 0.8 m

Rearranging the formula to solve for u:

u² = v² - 2as u² = 0 - 2 \* 9.81 \* 0.8 u² = -15.696 (negative velocity squared doesn't have a physical meaning, so we take the absolute value) u ≈ √(15.696) ≈ 3.96 m/s (we take the positive square root as the initial velocity is upwards)

1. **Calculate the deceleration (a) experienced during impact:**

We know the initial velocity (u) is 3.96 m/s, the final velocity (v) is 0 m/s, and the time taken (τ) to come to a stop is 0.002 seconds. We can use the formula:

v = u + a τ

0 = 3.96 + a \* 0.002 a = - (3.96 / 0.002) ≈ -1980 m/s² (negative sign indicates deceleration)

1. **Calculate the Fragility Factor (G):**

The fragility factor (G) is the ratio of the deceleration experienced during impact (a) to the acceleration due to gravity (g).

G = a / g

G = -1980 m/s² / 9.81 m/s² ≈ -202 (negative sign indicates the deceleration force is opposite to gravity)

**Interpretation:**

The fragility factor (G) of -202 indicates a very high deceleration force experienced by the cup during impact. Since it's negative, it signifies a force acting in the opposite direction of gravity. A higher G-value (positive or negative) represents a greater impact force, making the cup more prone to damage.

**Note:**

This calculation assumes a simplified scenario. In real-world drops, the impact might not be perfectly vertical, and the material properties of the cup would also influence the outcome.

1. **What thickness of expanded polystyrene foam would be required to protect this cup, dropped from the same height, knowing that the cushion factor for EPS is 2.6**

**(3 marks)**

## Calculating Required Thickness of EPS Foam for Cup Protection

We can calculate the required thickness of the expanded polystyrene (EPS) foam using the following approach:

1. **Allowable Deceleration for the Cup to Survive:**

We know the cup likely won't survive the initial impact of -1980 m/s² (calculated in the previous question). To protect the cup, the EPS foam needs to absorb most of the impact force, reducing the deceleration experienced by the cup to a tolerable level.

Let's assume a safe deceleration for the cup (a\_safe) to be significantly lower than the initial impact deceleration. We can choose a value like a\_safe = -50 m/s² (negative sign indicates deceleration).

1. **Cushion Factor of EPS:**

The cushion factor (CF) of EPS is given as 2.6. This factor represents the ability of the EPS foam to absorb impact force and reduce the deceleration experienced by the object.

1. **Relating Deceleration and Cushion Factor:**

The allowable deceleration (a\_safe) and the initial deceleration (a) are related to the cushion factor (CF) by the following equation:

a\_safe = a / CF

where:

* a\_safe = allowable deceleration for the cup to survive (m/s²)
* a = initial deceleration experienced during impact (m/s²)
* CF = cushion factor of EPS foam

1. **Solving for Required Thickness:**

The specific thickness of the EPS foam depends on the material properties of the foam itself, which are not given in this scenario. However, we can derive a general formula that relates the required thickness (d) to the other known factors.

The deceleration experienced by an object impacting a cushioning material is related to the material's properties and the thickness of the material. In simplified terms, a thicker material will provide greater deceleration. We can represent this relationship with a constant (k) specific to the EPS foam material being used.

a = k / d

where:

* a = deceleration experienced by the object (m/s²)
* k = constant specific to the EPS foam material (m²/s²)
* d = thickness of the EPS foam (m)

Combining this equation with the relationship between allowable deceleration and cushion factor, we get:

a\_safe = (k / d) / CF

Solving for the thickness (d):

d = k / (a\_safe \* CF)

1. **Data Limitations and Next Steps:**

Unfortunately, we cannot solve for the exact thickness (d) of the EPS foam without knowing the constant (k) specific to the particular EPS foam material. This constant would typically be obtained from the material manufacturer's data sheets or through specific impact tests with the chosen foam.

However, the derived formula provides a framework for calculating the required thickness. Once you have the value of ‘k’ for your chosen EPS foam, you can plug it into the formula along with the desired safe deceleration (a\_safe) and the cushion factor (CF) of EPS (2.6) to determine the necessary thickness (d) of the foam padding to protect the cup from damage during the drop.

1. **What are the internal dimensions of a case required to pack this cup in EPS if the dimensions of the cup are 150 x 130 x 130 mm**

**(3 marks)**

To determine the internal dimensions of a case required to pack the cup in EPS foam, we need to consider several factors:

1. **Cup Dimensions:** The cup itself measures 150 mm (length) x 130 mm (width) x 130 mm (height).
2. **EPS Foam Thickness:** As calculated in the previous question, the exact thickness (d) of the EPS foam depends on the specific material properties (represented by the constant k) and the desired safe deceleration for the cup. However, we can design the case assuming a certain thickness range for the EPS foam.
3. **Clearance for Packing:** We need some clearance around the cup within the case to ensure proper cushioning and prevent the cup from contacting the case walls during transport or handling. A typical clearance range might be 20-30 mm on all sides.

Here's how to calculate the internal dimensions of the case:

**Internal Length (L\_internal):**

L\_internal = Cup length (L) + 2 \* Clearance

L\_internal = 150 mm + 2 \* (Clearance)

**Internal Width (W\_internal):**

W\_internal = Cup width (W) + 2 \* Clearance

W\_internal = 130 mm + 2 \* (Clearance)

**Internal Height (H\_internal):**

H\_internal = Cup height (H) + 2 \* Clearance

H\_internal = 130 mm + 2 \* (Clearance)

**Example Calculation (assuming 25 mm clearance):**

L\_internal = 150 mm + 2 \* 25 mm = 200 mm W\_internal = 130 mm + 2 \* 25 mm = 180 mm H\_internal = 130 mm + 2 \* 25 mm = 180 mm

Therefore, with this example clearance of 25 mm, the internal dimensions of the case would be:

* Length (L\_internal): 200 mm
* Width (W\_internal): 180 mm
* Height (H\_internal): 180 mm

**Important Note:**

This is just an example calculation. The actual clearance value and the specific EPS foam thickness will depend on your specific requirements for cup protection, desired level of snugness within the case, and the properties of the chosen EPS foam. You might need to adjust the clearance based on your chosen foam thickness to ensure the cup is centered and well-cushioned within the case.

1. **Packaged products sometimes get dropped from a height. Briefly discuss some of the assumptions made when designing packaging that may be dropped.**

**(7 marks)**

Here are some key assumptions made when designing packaging for potential drops:

* **Drop Height and Orientation:** While the exact drop height might be unknown, packaging is often designed to withstand drops from a specific range (e.g., conveyor belt height, typical warehouse shelf height). Additionally, it's assumed that drops can occur from various orientations - top, bottom, side - to account for handling mishaps or unexpected impacts during transportation.
* **Material Properties:** Packaging materials are chosen based on their ability to absorb impact energy and distribute forces. Common assumptions include the material's stiffness, strength, and cushioning properties.
* **Stacking and Compression:** Packaging is designed to handle the weight of other packages stacked on top of it. Assumptions are made about the total stacking weight and how the packaging will deform or compress under such loads.
* **Fragility of Contents:** The fragility of the product itself is a crucial consideration. Packaging is designed to protect the product from damage based on its susceptibility to breakage, crushing, or deformation during a drop.
* **Vibration and Handling:** Packaging is assumed to experience vibrations during transportation, which can weaken materials or loosen seals. Assumptions are made about the vibration intensity and duration to ensure the packaging maintains its integrity.
* **Environmental Conditions:** Packaging is designed to withstand potential exposure to temperature extremes, humidity, or moisture during storage or transport. Assumptions are made about the range of environmental conditions the packaging might encounter.
* **Cost Efficiency:** Packaging design aims to achieve the desired level of protection while optimizing material usage and production costs.

These assumptions guide the selection of materials, design features (e.g., cushioning, internal dividers), and testing procedures to ensure that the packaging can adequately protect the product during a drop or other handling mishaps throughout the supply chain.

**Question 5 (25 marks)**

1. **Briefly discuss five ways in which packaging has supported the development of modern societies.**

**(10 marks)**

Packaging has played a significant role in supporting the development of modern societies in various ways:

1. \*\*Food Preservation\*\*: Packaging has enabled the preservation and transportation of food over long distances, reducing food spoilage and ensuring a stable food supply for growing populations. This has contributed to improved nutrition and health outcomes in modern societies.

2. \*\*Product Safety\*\*: Packaging provides a protective barrier that safeguards products from contamination, tampering, and damage. By ensuring product safety and integrity, packaging has enhanced consumer trust and confidence in the products they purchase.

3. \*\*Convenience and Efficiency\*\*: Modern packaging designs have made products more convenient to use, store, and transport. From single-serve portions to resealable packages, packaging innovations have improved the overall consumer experience and efficiency in daily life.

4. \*\*Branding and Marketing\*\*: Packaging serves as a powerful tool for branding, marketing, and communication. Eye-catching designs, logos, and product information on packaging have helped companies differentiate their products, build brand recognition, and attract consumers in competitive markets.

5. \*\*Waste Reduction and Sustainability\*\*: Packaging advancements have led to the development of eco-friendly and sustainable packaging solutions. From recyclable materials to biodegradable packaging, modern societies are increasingly focused on reducing waste and environmental impact through innovative packaging practices.

**b) Discuss what you understand by the term “an environmentally responsible pack”**

**(5 marks)**

An environmentally responsible pack refers to packaging that is designed, produced, used, and disposed of in a manner that minimizes its environmental impact throughout its lifecycle. This type of packaging aims to reduce resource consumption, waste generation, and pollution, while promoting sustainability and environmental stewardship. An environmentally responsible pack considers factors such as material selection, production processes, energy efficiency, recyclability, biodegradability, and overall environmental footprint. It aims to strike a balance between meeting the functional and marketing needs of the product while minimizing its negative effects on the environment. Key characteristics of an environmentally responsible pack include:

1. \*\*Resource Efficiency\*\*: Optimal use of materials and resources to minimize waste and reduce the environmental footprint of the packaging.

2. \*\*Recyclability\*\*: Packaging that is designed for easy recycling or reuse, promoting a circular economy and reducing the amount of waste sent to landfills.

3. \*\*Biodegradability\*\*: Packaging materials that can naturally decompose without leaving harmful residues, contributing to a more sustainable waste management system.

4. \*\*Energy Efficiency\*\*: Packaging that is produced using energy-efficient processes and technologies to reduce greenhouse gas emissions and energy consumption.

5. \*\*Minimal Environmental Impact\*\*: Packaging that is designed to have minimal impact on ecosystems, water resources, and air quality throughout its lifecycle.

Overall, an environmentally responsible pack aligns with principles of sustainability, conservation, and environmental protection, aiming to reduce the environmental burden associated with packaging while meeting the functional and marketing requirements of the product.

**c)** **Using examples, describe what you would consider when designing such a pack**

**(4 marks)**

**When designing an environmentally responsible pack, there are several key factors I would consider, using examples to illustrate:**

1. Material Selection:

- Example: Using recycled plastic or bio-based materials like PLA (polylactic acid) derived from renewable resources like corn or sugarcane, instead of conventional petroleum-based plastics.

2. Recyclability:

- Example: Designing a mono-material package, such as a PET bottle, that can be easily recycled, rather than using multi-layer or multi-material structures that are more difficult to recycle.

3. Minimizing Packaging Weight and Volume:

- Example: Lightweighting the packaging by reducing the thickness of plastic films or using thinner glass or metal, without compromising product protection, to reduce resource consumption and transportation impacts.

4. Reusability and Refillability:

- Example: Developing refillable packaging systems, such as reusable glass bottles for beverages, to encourage consumers to reuse the packaging and reduce waste.

5. Biodegradability and Compostability:

- Example: Selecting packaging materials that are certified as biodegradable or compostable, like plant-based bioplastics, to enable proper end-of-life disposal and reduce landfill waste.

6. Renewable Energy in Production:

- Example: Powering the packaging manufacturing process with renewable energy sources, such as solar or wind power, to minimize the carbon footprint of production.

7. Responsible Waste Management:

- Example: Designing packaging that is compatible with existing recycling or composting infrastructure in the target markets, ensuring the packaging can be properly disposed of after use.

8. Informative Labeling:

- Example: Providing clear and transparent labeling on the packaging to inform consumers about the environmental attributes of the pack, such as recycled content or recyclability, to encourage responsible disposal.

By considering these factors and incorporating relevant examples, the design of an environmentally responsible pack can minimize the overall environmental impact throughout the product's lifecycle, from resource extraction to end-of-life disposal or recycling.

1. **What is a carbon footprint (2 marks) and briefly discuss the reasons why you would calculate it (4 marks)**

**(6 marks)**

\*\*Carbon Footprint\*\*: A carbon footprint is a measure of the total amount of greenhouse gases, specifically carbon dioxide, and other carbon compounds emitted directly or indirectly by human activities. It quantifies the impact of these emissions on the environment and climate change.

\*\*Reasons for Calculating Carbon Footprint\*\*:

1. \*\*Environmental Impact\*\*: Calculating the carbon footprint helps individuals and organizations understand their contribution to climate change and environmental degradation, allowing them to take steps to reduce their impact.

2. \*\*Sustainability\*\*: By measuring the carbon footprint, businesses can identify areas where they can reduce emissions, improve energy efficiency, and adopt sustainable practices to minimize their environmental impact.

3. \*\*Compliance and Reporting\*\*: Many regulatory bodies require businesses to report their carbon emissions. Calculating the carbon footprint ensures compliance with regulations and helps in reporting accurate data.

4. \*\*Cost Savings\*\*: Understanding the carbon footprint can lead to cost-saving opportunities through energy efficiency measures, waste reduction, and sustainable practices, ultimately improving the bottom line.