

SUMMER EXAMINATIONS 2020

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

**COURSE:** **CPD** **Diploma** **in** **Packaging** **Technology**

**DATE:** **13th** **May** **2020**

**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.

**Question** **1** **(25** **marks)**

1. Briefly explain what the Industrial Revolution was **(2** **marks)**
2. Describe what changed during this period compared to previous society **(7** **marks)**
3. Discuss how the industrial revolution affected packaging methods. **(7** **marks)**

Recovery is a broad term that can apply to i) Recycling, ii) Energy Recovery (Incineration), or iii) Composting and Biodegradation.

1. Discuss what must be considered for each of these three categories when choosing a packaging material **(3** **X** **3** **marks)**

**Question** **2** **(25** **marks)**

Packaging is produced in large quantities, particularly for the FMCG market and is shipped and displayed stacked and under compression forces. Discuss the causes of compression hazards and the effects of these hazards.

# (15 marks)

List five Hazards of Distribution and briefly suggest a solution to deal with each issue.

**(10** **marks)**

**Question** **3** **(25** **marks)**

1. Define the Functions of Packaging.

# (5 marks)

1. List and explain the different levels of packaging.

# (10 marks)

1. Evaluate how the various levels of packaging perform the functions of packaging for their product for two of the following packs. Focus on the top 3 relevant functions, and show in order of importance. Give a brief reason for your choices.
   * Large Screen TV
   * Egg box for 6 eggs
   * SRP for ground coffee bags
   * 3 pack tins of beans

**(2** **X** **5** **marks**)

**Question** **4** **(25** **marks)**

1. Calculate the fragility factor, G for a glass bottle dropped from a height of 900 mm that decelerates to 0 on impact in 0.002 seconds.

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

v: final velocity (m/s) u: initial velocity (m/s) a: acceleration (m/s/s)

s: distance travelled (m) τ: time taken(s)

g: acceleration due to gravity (9.81m/s/s)

# (12 marks)

1. What thickness of expanded polyurethane foam (EPU) would be required to protect this cup, dropped from the same height, knowing that the cushion factor for EPU is 1.4

# (3 marks)

1. What are the internal dimensions of a container required to pack this cup in EPU if the dimensions of the bottle are 90 mm in diameter and 150 mm high?

# (3 marks)

1. Imagine you have been asked to hire an external test centre or laboratory to perform packaging testing. Briefly discuss the factors you would consider choosing such a centre.

**(7** **marks)**

**Question** **5** **(25** **marks)**

Understanding your product and how it will be affected by, and react to, the distribution supply chain challenges, is crucial to specifying the right level and performance of packaging.

1. Select a particular product and envision it packed and palletised ready for distribution. State the product and describe briefly, the various levels of packaging used.

# (7 marks)

1. What are the key questions you must ask, to understand the challenges faced in distribution?

**(18** **marks)**

**Question** **1** **(25** **marks)**

1. **Briefly explain what the Industrial Revolution was (2 marks)**

* Handcraft to Machines: Production moved away from things being made by hand to machines doing the work, allowing for much faster and more efficient output.
* Agrarian Economy to Manufacturing: Societies went from relying on agriculture as their main source of income to being centered around manufacturing goods.
* New Power Sources: Steam power became a key player, replacing water power and allowing factories to be built anywhere, not just near rivers.
* Rural Life to Urban Life: As jobs moved to factories, people migrated from farms to cities, leading to a boom in their size.

The Industrial Revolution transformed packaging by introducing mechanization, innovative materials, and mass production techniques. Beginning in the late 18th century, it revolutionized packaging by replacing handcrafted methods with machinery like steam-powered presses and assembly lines. This period also saw the development of new materials such as cardboard, paperboard, and eventually plastics, enabling more efficient and cost-effective packaging solutions. The Industrial Revolution in packaging played a crucial role in facilitating the mass distribution of goods and laying the groundwork for modern packaging practices.

1. **Describe what changed during this period compared to previous society (7 marks)**

Production:

* Machine Power: Machines replaced manual labor, drastically increasing production speed and efficiency. This led to a massive surge in the quantity of goods produced.
* Factory System: Production shifted from homes and workshops to centralized factories. This brought workers, machines, and materials together for streamlined production.

Economy:

* From Agrarian to Manufacturing: Societies transitioned from relying on agriculture for income to manufacturing goods as the economic driver. This led to a rise in new industries.

Society:

* Urbanization: As factories offered jobs, people migrated from rural areas to cities, causing rapid urban growth. This often resulted in overcrowded and sometimes unsanitary living conditions.
* Social Classes: The rise of factories created a new working class of factory workers. The wealthy class that owned the factories grew even more powerful.
* Working Conditions: Factory work was often long hours, dangerous, and repetitive, especially for women and children who also joined the workforce.

Overall Impact:

* Standardization: Mass production led to standardized goods, making them more affordable for many people.
* Innovation: The need for better machinery and processes fueled a constant stream of inventions and innovations.
* Global Trade: Increased production led to a rise in global trade, with countries exporting manufactured goods.

1. Economic Transformation: The shift from agrarian economies to industrialized ones occurred, marked by the rise of factories and mass production. This led to significant increases in productivity and wealth generation.
2. Technological Advancements: Innovations in machinery, such as the steam engine, transformed production processes. This led to the mechanization of tasks that were previously done manually, resulting in increased efficiency and output.
3. Urbanization: Industrialization drew people from rural areas to urban centers where factories were located, leading to rapid urbanization. This shift in population patterns reshaped societies and created new social dynamics.
4. Social Changes: The Industrial Revolution brought about changes in social structures and class relations. A new working class emerged, often working in harsh conditions in factories, while industrialists and capitalists amassed significant wealth.
5. Transportation and Communication: Advances in transportation, including the development of railways and steamships, revolutionized trade and communication networks. This facilitated the movement of goods and people over long distances, further driving economic growth.
6. Impact on the Environment: Industrialization had significant environmental consequences, including pollution and deforestation. The reliance on fossil fuels for energy production contributed to air and water pollution, leading to long-term environmental degradation.
7. Cultural Shifts: The Industrial Revolution sparked cultural changes, including shifts in artistic movements, literature, and social attitudes. It led to the rise of consumer culture as mass-produced goods became more accessible to a broader population.
8. **Discuss how the industrial revolution affected packaging methods. (7 marks)**

* Mass Production: Factories churned out vast quantities of goods, demanding faster and more efficient ways to package them. Traditional methods like handmade wooden crates and cloth bags couldn't keep pace.
* Transportation Advancements: Steam-powered trains and ships facilitated the movement of goods over longer distances. Packaging needed to be more durable and protective to withstand these journeys.
* Rise of Consumerism: With a growing middle class came a demand for more diverse and readily available consumer goods. Appealing packaging became a way to attract buyers and differentiate products.

Here's how packaging evolved during the Industrial Revolution:

* New Materials: The development of new materials like corrugated cardboard (invented in 1817) provided lighter, cheaper, and more stackable options compared to wooden crates. Tin cans (invented in 1810) offered a versatile and airtight container for food and other products. Glass production became faster and cheaper, making glass bottles more widely used.
* Standardization: With mass production, packaging sizes became more standardized to fit efficiently on shelves and during transportation. This also allowed for the development of machines for faster filling and sealing of packages.
* Branding and Marketing: The rise of consumerism led to the use of packaging for branding and marketing purposes. Labels with colorful designs and brand logos became commonplace. This helped to differentiate products and create brand loyalty.

However, there were also downsides:

* Environmental Impact: The increased use of some materials like metal and glass, while durable, raised concerns about waste disposal. Additionally, deforestation became a concern as wood was used for paper and cardboard production.

**Recovery is a broad term that can apply to i) Recycling, ii) Energy Recovery (Incineration), or iii) Composting and Biodegradation.**

1. **Discuss what must be considered for each of these three categories when choosing a packaging material** **(3** **X** **3** **marks)**

Recycling:

* Material Compatibility: Packaging materials must be compatible with existing recycling infrastructure. Materials that are commonly recycled, such as certain types of plastics, paper, and metals, are preferred because they can be easily sorted and processed.
* Recyclability: Packaging materials should ideally be recyclable after use. This means they can be collected, sorted, and processed into new materials or products. Materials like PET (polyethylene terephthalate) and HDPE (high-density polyethylene) plastics are highly recyclable.
* Design for Recycling: Packaging design plays a crucial role in recyclability. Materials that are easy to separate, clean, and process are preferred. Minimizing the use of mixed materials and removing non-recyclable components, such as certain types of coatings or additives, can improve recyclability.

Energy Recovery (Incineration):

* Calorific Value: Packaging materials suitable for energy recovery typically have a high calorific value, meaning they release a significant amount of energy when burned. Materials such as plastics and paper-based products can be effectively incinerated to generate heat or electricity.
* Emissions and Residue: Consideration must be given to the emissions generated and the residue left behind during incineration. Packaging materials that produce minimal pollutants and ash residue are preferred for energy recovery. For instance, some plastics release harmful gases when burned, so alternatives with lower emissions may be preferable.
* Regulatory Compliance: Regulations regarding waste incineration vary by region and may impose limits on emissions and residue disposal. Packaging materials must comply with these regulations to ensure environmentally responsible energy recovery practices.

Composting and Biodegradation:

* Biodegradability: Packaging materials suitable for composting or biodegradation should be capable of breaking down into natural elements within a reasonable timeframe under specific conditions, such as moisture, heat, and microbial activity. Materials like certain types of bioplastics or compostable paper products are designed for this purpose.
* Certification Standards: Packaging materials labeled as compostable or biodegradable should meet recognized certification standards to ensure their environmental claims are valid. Certification programs such as ASTM D6400 or EN 13432 specify criteria for compostability and biodegradability.
* End-of-Life Management: Proper disposal infrastructure, such as industrial composting facilities, must be available to effectively manage compostable or biodegradable packaging materials. In regions lacking such infrastructure, these materials may not degrade as intended, leading to environmental concerns.

**Question** **2** **(25** **marks)**

1. **Packaging is produced in large quantities, particularly for the FMCG market and is shipped and displayed stacked and under compression forces. Discuss the causes of compression hazards and the effects of these hazards.**

# (15 marks)

FMCG (Fast Moving Consumer Goods) products are often packaged in large quantities for efficiency and cost-effectiveness. However, during shipping, storage, and display, these packages are subjected to significant compression forces, leading to potential hazards. Here's a breakdown of the causes and effects of compression hazards:

Causes of Compression:

* Stacking: Warehouses and retail stores often stack pallets of packaged goods high to maximize space utilization. This weight from stacked packages creates significant downward pressure on the lower ones.
* Transportation: During transportation by truck, train, or ship, packages experience compression due to the weight of other cargo stacked on top and the dynamic forces of acceleration, braking, and turning.
* Handling: Manual handling of packages, especially during loading and unloading, can lead to accidental squeezing or dropping, causing compression damage.

Effects of Compression Hazards:

* Product Damage: Excessive compression can damage the product inside the packaging. For fragile items like food products or electronics, this can lead to breakage, crushing, or deformation.
* Package Collapse: If the packaging material is not strong enough to withstand compression, it can collapse or buckle. This can damage the product inside and make it unsellable.
* Loss of Stacking Strength: Repeated compression can weaken the packaging material, reducing its ability to support the weight of stacked packages. This can lead to further product damage and safety concerns.
* Reduced Shelf Appeal: Packages that are damaged due to compression may appear dented, misshapen, or torn, making them less appealing to consumers.

Mitigating Compression Hazards:

* Packaging Design: Designing packaging with strong, rigid materials like reinforced cardboard or corrugated plastic can help to withstand compression forces. Using internal dividers or cushioning materials can further protect the product.
* Stacking Limits: Clearly marking weight limitations on packaging and establishing stacking limits in warehouses and stores can help to prevent excessive compression.
* Proper Handling: Training workers on proper handling techniques can minimize accidental compression damage during loading, unloading, and transportation.
* Void Fillers: Using void fillers like packing peanuts, air pillows, or bubble wrap can help to prevent movement and compression within the package itself.

1. **List five Hazards of Distribution and briefly suggest a solution to deal with each issue.**

**(10 marks)**

Impact Damage:

* Hazard: Products may suffer damage due to impacts during handling, loading/unloading, or transportation.
* Solution: Use protective packaging materials such as bubble wrap, foam inserts, or corrugated cardboard to cushion products and absorb shocks. Additionally, consider reinforcing outer packaging with durable materials to provide added protection.

Compression Damage:

* Hazard: Stacking or improper storage can subject packages to compression forces, leading to deformation or collapse.
* Solution: Optimize packaging design to withstand compression by using sturdy materials and reinforcing vulnerable areas. Implement proper stacking and handling procedures to minimize pressure on packages during storage and transportation.
* Vibration Damage:
* Hazard: Continuous vibrations during transit can cause products to shift, rub against each other, or experience fatigue failure.
* Solution: Use vibration-dampening materials such as foam inserts, air cushions, or void fill to stabilize products within packaging. Securely seal packages and pallets to prevent movement and minimize the effects of vibration.

Temperature and Humidity Damage:

* Hazard: Extreme temperatures or humidity levels can adversely affect product quality, integrity, or shelf life.
* Solution: Select packaging materials with appropriate barrier properties to protect products from temperature and moisture fluctuations. Consider using insulated packaging or desiccants to regulate internal conditions and mitigate the impact of environmental factors.

Puncture/Tear Damage:

* Hazard: Sharp objects, rough handling, or abrasive surfaces can puncture or tear packaging, exposing products to damage or contamination.
* Solution: Choose packaging materials with puncture-resistant properties, such as thicker films or reinforced cardboard. Utilize protective features like corner guards or edge protectors to prevent punctures and tears. Additionally, ensure proper handling procedures and use caution when loading/unloading packages to minimize the risk of damage.

**Question** **3** **(25** **marks)**

1. **Define the Functions of Packaging.**

# (5 marks)

* Containment: Packaging must contain and hold the product, depending on its physical form and nature. For example, a free-flowing powder or a viscous liquid requires appropriate containment.
* Protection: Packaging must prevent mechanical damage to the product during distribution, handling, and storage.
* Preservation: Packaging must prevent or inhibit chemical, biochemical, and microbiological spoilage of the product, preserving its quality and safety.
* Information: Packaging must provide legal and marketing information about the product, such as ingredients, usage instructions, and branding.
* Convenience: Packaging should be easy to handle, open, and use for both the supply chain and the consumer.
* Presentation: Packaging design, materials, shape, and graphics can enhance the product's visual appeal and brand image.
* Promotion: Packaging can be used to promote the product, such as through special offers or new product launches.
* Economy: Packaging should optimize costs throughout the supply chain, from production to distribution and disposal.
* Environmental responsibility: Packaging should minimize environmental impact through sustainable materials, design, and end-of-life management.

1. **List and explain the different levels of packaging.**

* Primary Packaging: This is the packaging that comes into direct contact with the product. It is designed to protect the product during storage, transportation, and use. Examples include bottles, cans, and jars. Primary packaging is crucial for maintaining product integrity and freshness
* Secondary Packaging: Secondary packaging is used to group primary packages together for easier handling, transportation, and display. It provides additional protection during distribution and can include items like cardboard boxes, shrink wrap, or trays. Secondary packaging helps in branding, marketing, and enhancing the product's visual appeal
* Tertiary Packaging: Tertiary packaging is designed for bulk handling and shipping of multiple units of primary or secondary packaging. It includes pallets, stretch wrap, and containers used for transporting goods in larger quantities. Tertiary packaging ensures efficient storage, handling, and transportation of products in bulk quantities

1. **Evaluate how the various levels of packaging perform the functions of packaging for their product for two of the following packs. Focus on the top 3 relevant functions, and show in order of importance. Give a brief reason for your choices.**
   * **Large Screen TV**
   * **Egg box for 6 eggs**
   * **SRP for ground coffee bags**
   * **3 pack tins of beans**

1. Large Screen TV:

* Functions (Order of Importance):
  + Protection: This is the most crucial function for a large screen TV. The packaging needs to be exceptionally strong and secure to prevent damage from impacts, vibrations, or crushing during transportation.
  + Containment: While important, containment is secondary here as the TV itself is bulky and wouldn't require strict shape-holding.
  + Communication and Marketing: While some branding information might be present, it's not a primary function for the TV itself.
* Levels and Performance:
  + Primary Packaging: Usually heavy-duty cardboard with internal foam or bubble wrap cushioning prioritizes protection.
  + Secondary Packaging: Often a wooden crate or reinforced cardboard box further enhances protection during transportation.

2. Egg Box for 6 Eggs:

* Functions (Order of Importance):
  + Protection: Eggs are fragile and highly susceptible to breakage. The packaging needs to prioritize preventing damage from bumps, drops, and crushing.
  + Containment: The egg carton keeps the eggs separated and organized, preventing them from hitting each other and reducing the risk of breakage.
  + Communication and Marketing: While some branding might be present, it's not the primary function.
* Levels and Performance:
  + Primary Packaging: The molded pulp or plastic egg carton separates and cushions the eggs, focusing on protection and containment.
  + Secondary Packaging: A cardboard box containing multiple egg cartons provides additional protection during transportation and storage.

1. SRP (Single-Serve Retail Pack) for Ground Coffee Bags:

* Functions (Order of Importance):
  + Containment and Preservation: The packaging needs to keep the coffee grounds fresh and prevent them from spilling or losing their aroma.
  + Protection: While some protection is needed, the single-serve format minimizes the risk of major damage compared to bulkier products.
  + Communication and Marketing: Eye-catching graphics and information about the coffee origin, roast, and flavor profile are crucial for attracting customers.
* Levels and Performance:
  + Primary Packaging: The individual coffee bag, typically made of foil or a combination of foil and paper, prioritizes containment and preservation. It seals the coffee grounds and maintains freshness.
  + Secondary Packaging: A cardboard box or pouch containing multiple coffee bags provides some additional protection during transportation and allows for displaying product information and branding for communication and marketing.

2. 3 Pack Tins of Beans:

* Functions (Order of Importance):
  + Containment and Preservation: The packaging needs to keep the beans fresh and prevent them from spilling or losing their flavor.
  + Protection: The tins offer good protection against crushing and some impacts compared to flexible packaging.
  + Communication and Marketing: The tins themselves can be a canvas for branding and product information.
* Levels and Performance:
  + Primary Packaging: The individual tin for each bean variety prioritizes containment and preservation. It seals the beans and protects them from light and air.
  + Secondary Packaging: A cardboard box or sleeve containing the three tins provides minimal additional protection but allows for displaying branding and product information on a larger surface for communication and marketing.

**Question 4 (25 marks)**

1. **Calculate the fragility factor, G for a glass bottle dropped from a height of 900 mm that decelerates to 0 on impact in 0.002 seconds.**

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

**v: final velocity (m/s) u: initial velocity (m/s) a: acceleration (m/s/s)**

**s: distance travelled (m) τ: time taken(s)**

**g: acceleration due to gravity (9.81m/s/s)**

# (12 marks)

Find the initial velocity (u) of the bottle just before impact.

Calculate the deceleration (a) experienced by the bottle during impact.

Determine the fragility factor (G) based on the deceleration.

Step 1: Find Initial Velocity (u)

We know the height (s) from which the bottle is dropped (s = 0.9 m) and the acceleration due to gravity (g = 9.81 m/s/s). We can use the formula:

v² = u² + 2as

Here, v = 0 (final velocity at impact), s = 0.9 m, and a = g (assuming no air resistance).

0² = u² + 2 \* 9.81 \* 0.9

u² = - (2 \* 9.81 \* 0.9) (We can ignore the negative sign for velocity magnitude)

u ≈ √(17.66) ≈ 4.2 m/s

Step 2: Calculate Deceleration (a)

We know the initial velocity (u = 4.2 m/s) and the time taken for deceleration (τ = 0.002 s). We can use the formula:

v = u + a τ

Here, v = 0 (final velocity at impact).

0 = 4.2 + a \* 0.002

a = - (4.2 / 0.002) ≈ -2100 m/s/s (Negative sign indicates deceleration)

Step 3: Determine Fragility Factor (G)

The fragility factor (G) is a relative measure of an object's ability to withstand impact. It's generally not a standardized value and may vary depending on the specific material and testing methodology used. However, we can estimate it based on the deceleration experienced.

Here's a general guideline (note: this is not a universal standard and may vary):

G > 1000: Very high fragility (low impact tolerance)

100 < G < 1000: Medium fragility

G < 100: Low fragility (high impact tolerance)

In this case, the deceleration (a) is -2100 m/s/s. Since this value is much greater than 1000, it suggests the glass bottle has a high fragility factor (G) and likely a low tolerance for impact.

1. **What thickness of expanded polyurethane foam (EPU) would be required to protect this cup, dropped from the same height, knowing that the cushion factor for EPU is 1.4**

# (3 marks)

Reduce Deceleration with Cushion Factor:

We know the deceleration experienced by the unprotected bottle (a = -2100 m/s/s) and the cushion factor of EPU (CF = 1.4). The cushion factor essentially reduces the impact force felt by the product.

Deceleration with EPU (a\_epu) = Deceleration without EPU (a) / Cushion Factor (CF)

a\_epu = -2100 m/s/s / 1.4 ≈ -1500 m/s/s (The negative sign indicates deceleration)

Calculate Required Stopping Distance in EPU:

We know the initial velocity (u = 4.2 m/s) and the new deceleration with EPU (a\_epu = -1500 m/s/s). We need to find the distance (s\_epu) traveled within the EPU foam to bring the bottle to a complete stop (v = 0).

We can use the formula:

v² = u² + 2as\_epu

Here, v = 0 and a\_epu = -1500 m/s/s.

0² = 4.2² + 2 \* -1500 \* s\_epu

s\_epu ≈ (4.2² ) / (2 \* 1500) ≈ 0.0012 m (or 1.2 mm)

Therefore, approximately 1.2 mm of EPU foam padding would be required to absorb the impact and provide a similar level of protection as the original packaging for the glass bottle dropped from 900 mm.

1. **What are the internal dimensions of a container required to pack this cup in EPU if the dimensions of the bottle are 90 mm in diameter and 150 mm high?**

# (3 marks)

1. Determine the Required EPU Padding Thickness:

We know the EPU thickness needed to protect the cup is approximately 1.2 mm (as calculated previously).

2. Account for Padding on All Sides:

To ensure complete protection, the EPU padding needs to surround the cup on all sides. So, we need to add the padding thickness twice (for both sides) to each of the cup's dimensions.

3. Calculate Internal Container Dimensions:

Diameter:

Cup diameter + Padding on each side (2 \* EPU thickness)

Diameter = 90 mm + (2 \* 1.2 mm)

Diameter ≈ 92.4 mm

Height:

Cup height + Padding on each side (2 \* EPU thickness)

Height = 150 mm + (2 \* 1.2 mm)

Height ≈ 152.4 mm

Therefore, the internal dimensions of the container required to pack the cup with EPU padding would be approximately 92.4 mm in diameter and 152.4 mm in height.

1. **Imagine you have been asked to hire an external test centre or laboratory to perform packaging testing. Briefly discuss the factors you would consider choosing such a centre.**

**(7 marks)**

* Mechanical Testing:
  + Compression Testing: Measures the packaging's ability to withstand vertical loads and stacking forces.
  + Drop Testing: Evaluates the packaging's resistance to impact and shock during handling and transportation.
  + Vibration Testing: Simulates the effects of continuous vibration and transportation conditions on the packaging's integrity.
  + Tensile Testing: Determines the strength of packaging materials by subjecting them to tension forces.
  + Environmental Testing:
  + Temperature and Humidity Testing: Assesses the packaging's performance under different temperature and humidity conditions to evaluate its stability and resistance to moisture.
  + Thermal Cycling: Subjects the packaging to alternating temperature extremes to assess its dimensional stability and resistance to thermal stress.
  + UV Exposure Testing: Determines the packaging's resistance to UV radiation and its ability to protect the contents from light-induced degradation.
* Barrier Testing:
  + Gas Permeability Testing: Measures the packaging's ability to prevent the ingress or egress of gases, such as oxygen, carbon dioxide, or moisture.
  + Moisture Vapor Transmission Rate (MVTR) Testing: Determines the packaging's resistance to moisture vapor transmission, which is crucial for preserving product freshness and shelf life.
  + Oxygen Transmission Rate (OTR) Testing: Measures the packaging's oxygen barrier properties to prevent oxidation and spoilage of oxygen-sensitive products.
* Material Analysis:
  + Thickness Measurement: Determines the thickness of packaging materials to ensure uniformity and consistency.
  + Material Composition Analysis: Identifies the composition of packaging materials and verifies compliance with regulatory requirements.
  + Friction Testing: Evaluates the slip properties of packaging materials to assess their suitability for automated handling and processing.
* Durability Testing:
  + Abrasion Resistance Testing: Assesses the packaging's resistance to abrasion and wear during handling and transportation.
  + Rub Test: Determines the packaging's resistance to rubbing or friction, which can affect its appearance and print quality.
* Functional Testing:
  + Closure Integrity Testing: Ensures the integrity and functionality of closures, seals, and openings to prevent leakage or tampering.
  + Ease of Opening/Closing Testing: Evaluates the ease of opening and closing packaging to ensure user convenience and accessibility.
* Microbiological Testing:
  + Sterility Testing: Determines the absence of microorganisms in sterile packaging intended for medical or pharmaceutical applications.
  + Microbial Growth Testing: Assesses the packaging's resistance to microbial growth and contamination to ensure product safety and shelf stability.

**Question 5 (25 marks)**

**Understanding your product and how it will be affected by, and react to, the distribution supply chain challenges, is crucial to specifying the right level and performance of packaging.**

1. **Select a particular product and envision it packed and palletised ready for distribution. State the product and describe briefly, the various levels of packaging used.**

## Product: High-End Porcelain Dinnerware Set (16 Pieces)

**Distribution Scenario: The dinnerware set will be shipped from a manufacturer in China to a high-end department store in the United States. The shipment will involve ocean freight and truck transport within the US.**

Levels of Packaging:

1. Primary Packaging:  
   * Each individual plate, bowl, cup, and saucer will be wrapped in soft, protective tissue paper. This will prevent scratches and absorb any minor impacts.
   * Cups and mugs may have additional bubble wrap around the handles for extra protection.
2. Secondary Packaging:  
   * Sets of plates (dinner plates, salad plates, etc.) will be stacked with paper dividers between them to prevent them from rubbing against each other and chipping.
   * Cups and bowls may be placed in molded cardboard inserts to keep them separated and prevent them from clinking together during transport.
   * All components (plates, bowls, cups, saucers) will be carefully packed together in a sturdy cardboard box with enough void fill material (packing peanuts, air pillows) to prevent movement within the box.
3. Tertiary Packaging:  
   * Multiple cardboard boxes containing dinnerware sets will be stacked on a wooden pallet.
   * The pallet will be securely wrapped in heavy-duty plastic stretch wrap to ensure the boxes stay secure during transportation.
   * Strapping may be used for additional reinforcement, especially for tall stacks of pallets.

# (7 marks)

1. **What are the key questions you must ask, to understand the challenges faced in distribution?**

**(18 marks)**

**Product-related questions:**

* **Product fragility:** How susceptible is the product to damage from impacts, vibrations, or crushing?
* **Weight and dimensions:** What is the product's weight and size? This impacts handling, storage requirements, and potential stacking limitations.
* **Environmental sensitivities:** Is the product sensitive to temperature, humidity, or light?
* **Stackability:** Can the product packaging be safely stacked on top of each other?
* **Special handling requirements:** Does the product require any special handling instructions, such as "keep upright" or "fragile"?

**Distribution channel considerations:**

* **Transportation modes:** What modes of transportation will be used (truck, train, ship, air)? Each mode presents different challenges in terms of handling and potential for damage.
* **Distance and duration:** How far will the product travel, and what is the estimated delivery time? Longer distances and durations increase the risk of damage.
* **Storage conditions:** What are the storage conditions at different points in the supply chain? This could include warehouses with varying temperature and humidity control.
* **Climate variations:** Will the product be exposed to significant variations in temperature or humidity during transport or storage?
* **Handling practices:** How will the product be handled during loading, unloading, and storage? Rough handling can lead to damage.

**Regulatory and compliance factors:**

* **Customs regulations:** Are there any specific packaging or labeling requirements for the destination country?
* **Environmental regulations:** Are there restrictions on certain packaging materials due to environmental concerns?

**Cost considerations:**

* **Packaging costs:** What is the cost of different packaging materials and designs?
* **Transportation costs:** Do the packaging dimensions and weight significantly impact transportation costs?
* **Potential damage costs:** What are the potential costs associated with product damage during distribution?