ANSWER KEY TO ACCOMPANY:
Product Design by Paul Rodgers and Alex Milton

Introduction

1. (pp. 8-11)
   - consumer product – covers a wide range of designed objects generally for personal, family or household use e.g. lighting, domestic appliances, medical products, audio-video equipment, office equipment, motor cars, furniture, personal computers
   - one-off artistic works – classic designed products considered to be as much works of art as the works of a designer e.g. the iPod, Coca-Cola® bottle, Volkswagen Beetle car
   - consumer durables – a manufactured product that has a relatively useful life; designer is involved in product's packaging, branding, advertising and marketing rather than design of durable itself e.g. packaged butter, motor oil, bottled water, newspapers, fizzy drinks
   - bulk products – generally covers raw materials used in the manufacture of other products e.g. metal rolled sections, rod and bar stock plastics, woven sheet and foil, and laminates
   - industry products – items or assemblies that are bought by a manufacturing company for assembling their own products e.g. ball and roller bearings, electric motors and controllers, circuit boards, crane hooks and gas turbine engines for aircraft
   - industrial equipment products – self-contained devices (i.e. machines) that perform a complex function and are intended for use within industry e.g. industrial work-stations, machine tools, goods vehicles, earth-moving machinery and passenger aircraft
   - special purpose products – usually produced to order as single items (one of a kind) or a small series e.g. jigs, bespoke tooling, fixtures, special purpose robotics machinery, specialized manufacturing and assembly machinery
   - industrial plant – consists of industrial equipment products and devices to provide control and connections between them e.g. plant and components for water purification systems, electric power station equipment, telephone networks
2. (p. 14) design, research, marketing, manufacturing

Discussion/essay questions

1. What do you think is meant by 'product design'? Why is product design important? (pp. 6-8)
2. Discuss the role of the product designer today. How do you think this role has changed over recent years? How might it develop in the future? (pp. 12-13)

Chapter 1: Historical and cultural context

1. (p. 20) mass production
2. (pp. 20-21) discovery of electricity by Benjamin Franklin, the invention of the steam engine by James Watt
3. (p. 21) **c.** the incandescent light bulb
4. (p. 22) a return to nature and handcraft as an answer to the excessive development of industry, large cities and mass production
5. (pp. 23-24) because Japan ended its 200 year trade isolation through a treaty with the United States in 1854; Japanese art used imagery from nature and flat perspectives and block colouring which appealed to many Western artists
6. (p. 25) as a response to widely held worries that Germany's rapid industrialization and modernization were coming at the cost of its national culture
7. (p. 27) Walter Gropius
8. (p. 28) that it was necessary to create buildings and products that expressed the spirit of a new age and that would surpass the styles, materials and technologies of earlier work
9. (p. 28) False, Art Deco first appeared in Paris
10. (p. 29) because streamlining – the shaping of an object – was used in the design of a vast array of products from buses to prams, coffee machines to pencil sharpeners
11. (p. 32) functionality, simple forms, utility, durability, timelessness, order, clarity, solid workmanship, suitable materials, finished details, technology, environmental responsibility
12. (p. 33) dissatisfied with their working conditions and with the consumption-led 'good form' of many designed products
    protested against established design norms and the obsession with consumption
13. (p. 36) because China continued to experience dramatic shortages in domestic products up until the 1980s; up to this point the main concern of the country was to produce large quantities of goods and design was deemed less important with manufacturers using the same design of products for several decades without making any changes
14. (p. 39) It is widely acknowledged that the Italian groups **Studio Alchimia** and **Memphis** produced the first objects of Post-Modern design.
15. (p. 41) design which acknowledges the significance of an *individual* aesthetic as a 'functional' dimension of design, rather than a search for universal solutions associated with the Modernist ideal; tends to be experiential rather than theoretical, and poetic rather than literal
16. (p. 42) **Ready-made** products is a term that covers designed objects that are created by combining often mundane and utilitarian products in a new context.
17. (p. 51) a colourful, mass-produced, plastic-based, emotionally engaging consumer product with a curvilinear, flowing shape

Discussion/essay questions

1. Write an essay on the importance of the Industrial Revolution and the various reform movements of the nineteenth century in the development of product design. Consider significant inventions and the work of key manufacturers and artists/designers. (pp. 20-24)
2. Research in more detail either the Deutscher Werkbund or the Bauhaus in Germany in the first decades of the twentieth century. Consider why they were founded, key figures involved and the type of products created. (pp. 25-27)
3. What were the economic and political effects of World War II and how did they impact on design in the United States and Western Europe? Why do you think Italy emerged as one of the foremost design nations after the war? (pp. 30-31)
4. What is Post-Modernism? Where and why did it emerge? Why do you think it is still influential? (pp. 38-39)
5. Discuss design trends which have emerged at the beginning of the twenty-first century. Consider Critical design, blobjects and individualized products and the importance of advances in technology such as CAD, rapid prototyping and injection moulding. What future trends do you think might emerge? (pp. 50-54).

Chapter 2: Research, brief and specification

1. (pp. 58-59) background stage includes the gathering of information from users, clients and other individuals likely to be involved during the creation of the product methods used include interviews, literature reviews, questionnaires and surveys, cross-cultural comparisons, cultural probes
2. (p. 58) in an unstructured interview the interviewer asks users a series of open-ended questions and users are free to steer the content of the interview to cover the issues relevant to them, but in a structured interview the interviewer has a predetermined list of values that the user is asked to select from
3. (p. 59) advantage – effective way to elicit responses from a large number of people, useful way of ascertaining particular traits and values of many users relatively quickly disadvantage – low response rate, inability to probe responses
4. (pp. 60-62)
   - camera journals – involves users recording their daily activities via a written and photographic diary; useful for getting users to reveal real insights into their daily patterns of behaviour
   - narration – involves asking users to think and describe aloud while they are performing a specific activity or operating a product in a particular context; useful for identifying users' concerns, desires and motivations when using specific products, systems and services
   - focus groups – a form of group interview that capitalizes on the communication between participants in order to generate information; useful for generating ideas and developing an understanding on particular themes without having to reach a consensus
   - shadowing – involves the product designer tagging along with people to observe and gain a good understanding of their day-to-day routines; useful for

identifying potential design opportunities and learning first-hand how users interact with designed products, systems and services

- ethnography – about discovering cultural patterns and developing models to explain those patterns; involves observing people in order to examine everyday experiences, situations, environments, activities, relations, interactions and processes in rich detail; useful for investigating everyday social life and culture as a context for innovation and creativity
- personas – archetypal users with specific, objectives and needs based on real research; allow product designers to gain a good understanding of their customers' expectations and needs in a relatively cheap and straightforward manner

5. (pp. 62-63)
branding research – involves evaluating rival products and brands and comparing and contrasting them against your own product by using a series of questions
market research – involves observing how rival products are advertised, fitted into the brandscape and retailed
retail research – involves observing how people shop in a particular sector

6. (p. 64) to clearly define all of the aims and objectives identified through research and/or discussions with the client

7. (p. 65)
- marketing perspective – describes the anticipated product, its functionality and its market positioning with respect to the product's main competitors and brand imperatives
- technical perspective – specifies the constraints on investment for new tooling, existing parts or components that need to be reused; a preliminary PDS covering performance, cost and intended manufacture, and standards that need to be respected; usually clarifies or defines key functional criteria that are likely to influence a future design
- sales perspective – covers all aspects relating to sales and distribution, including the product's Return on Investment and sales planning

8. (pp. 68-69) pairwise comparison method, relative importance survey

9. (p. 72) PDS is a document that sets out exactly what is required of a product before it is designed
essential in the design process because helps both people who design and make the product but also those who eventually use it

10. (p. 72 and p. 231) In a PDS the **metric** is any element that can be measured.

Discussion/essay questions

1. Discuss the importance of the brief in the product design process. What questions is it important to consider when writing a brief? (pp. 64-65)

2. Why do you think identifying customer wants, needs and demands is such an important part of the product design process? What methods can you use to help you establish clear design specification targets? (pp. 67-69)

Chapter 3: Concept design

1. (p. 78) concept design is an approximate description of the technological, functional and aesthetic form of the product in development
2. (p. 78) in convergent thinking the designer follows an analytical process, developing the design in a sequential manner, but in divergent thinking the designer explores as many solutions as possible in a lateral manner, following all creative paths
3. (pp. 79-82)
   - brainstorming – highly efficient method of generating innovative concept proposals; helps design teams to generate and evaluate ideas through teamwork and collaboration
   - attribute listing – a specific idea-finding technique which identifies the key characteristics, or attributes, of the product or process in question; thinks up ways to change, modify or improve each attribute, compares and contrasts these changes with the initial product or process
   - analogical thinking – transfer of one idea from one context to another context; direct analogical thinking brings together a problem from one domain with familiar knowledge or another domain as a way to gain insight
   - idea checklists – checklist written specifically to help solve problems creatively
   - breaking the rules – method which enables designers to temporarily rewrite the social, cultural or physical rules impacting the problem to hand
   - lateral thinking – techniques which attempt to change concepts and perceptions by rejecting traditional step-by-step logic
   - mind mapping – mind map is a diagram used to represent ideas linked to, and arranged radially around, a central key word or idea; designers use them to generate ideas and help in the problem-solving and decision-making process
4. (p. 84) thematic sketches and schematic sketches
   thematic sketches – are the initial exploratory visions of how a proposed design may look and tend to be drawn in a fluid, dynamic and expressive manner; convey the product's physical form, characteristics and overall aesthetic
   schematic sketches – place less emphasis on the external styling or appearance of a design and focus on defining and working within a 'package' (the fixed dimensional parameters of a design)
5. (p. 84) False, GA is the master drawing which describes the final form of the design and the layout of its components
6. (p. 86) The art of 'colouring in' a sketch is known as **rendering**.
7. (pp. 88-90) CAD enables a designer to draw on a computer and to visualize designs three-dimensionally, whereas CAM (computer-aided manufacture) is the technology which enables CAD models to be produced/manufactured
8. (p. 91)

- one-point perspective – one vanishing point towards which all lines, except those normally at right angles to the viewers' sight line, will recede and converge
- two-point perspective – has two vanishing points, placed on the horizon to the left and right of the object
- three-point perspective – has vertical lines of an object converging towards a third vanishing point directly below or above it

9. (p. 92) to represent real or imagined three-dimensional objects on a two-dimensional surface

10. (p. 98)
- sketch model – a full-size or scale model that aims to capture the embryonic ideas emerging from the design team's initial concept development
- mock-up – a life-size physical model constructed from easily fabricated materials such as rigid card, wood and foam to evaluate the physical interaction, scale and proportion of product design concepts during the early stages of the process
- appearance model – a life-size/actual-size model whose primary purpose is to help evaluate the design's aesthetics and convey detailed finished, rather than product function
- test rig – a full-size or scale model that replicates a mechanical action or enables strength, stiffness, comfort or durability to be tested

11. (p. 101) by enabling designers to understand existing user experiences and context, explore and evaluate ideas and communicate them to an audience; enable the design team, users and clients alike to engage with a concept and prompt dialogue between all the stakeholders; facilitate informed decision-making and help ensure a streamlined development process that avoids costly mistakes or delays in bringing a product to market

12. (pp. 102-105)
- quick-and-dirty prototyping – used as quick way to communicate a concept idea to other members of the product design team; focus of method is on speed over quality of prototype building
- paper prototyping – used to quickly visualize, organize and articulate basic design concepts; product designers can use this method to sketch out functionality and usability aspects of concepts and evaluate them
- experience prototyping – useful tool for detecting unanticipated problems or opportunities as well as evaluating ideas
- role-playing – through participants adopting and acting out characters or roles the design team can understand users' personalities, motivations and backgrounds and begin to understand and empathize with actual users
- body storming – by imagining what it would be like if a concept existed, and acting out a scenario as if it exists, design teams can generate and evaluate behavioural concepts within a defined physical context
- empathy tools – can give designers a greater appreciation of what it is like for users with disabilities or special conditions to use products

- be your customer – useful method for detecting a client's perceptions of their customers
- try it yourself – allows the design team to sample the product being designed themselves
- scenario modelling – by devising a scenario carefully with characters, narrative and context, designers can evaluate whether their design ideas will work with their intended users
- scenario testing – involves the creation of future scenarios using media such as photography, film and video and asking users to provide feedback on them; useful method for communicating and evaluating early concepts to clients
- story boards – used to share concept designs with others, also as prompt for discussion in focus groups and interviews
- informance – an 'informative performance' scenario role-played by the design team that is based on insight and observations collected previously; effective method for creating a shared understanding of a design proposal and its implications
- rapid prototyping – range of methods that create detailed physical models of products from computer data; often used to check the design of parts before committing to production tooling

13. (pp. 105-106) concept selection is the process of narrowing a set of concept alternatives under consideration
CAD models, checklists, external decision, interviewing prospective or actual users, intuition, mock-up evaluation, multi-voting, product champion, pros and cons, protocol analysis, prototype and test, task analysis, matrix evaluation

Discussion/essay question

1. Discuss the role CAD now plays in the design process. What advantages are there with using CAD? Are there any disadvantages? (pp. 88-90)

Chapter 4: From manufacture to market

1. (p. 108) the process of transforming a product concept into a set of manufacturing drawings and documentation
2. (pp. 108-109)
   - product subdivision – breaking down of the design concept into a number of smaller units; subdivision continues down to component level
   - design and selection of components and sub-units – involves the designing, selection and sourcing of the component parts and assemblies that make up the product
   - integration of parts – sees the integration of parts into the final configuration of the product
   - product prototyping and testing – involves the final prototyping and testing of the design

- completion of manufacturing information set – completion and signing off of the manufacturing data and the approval to commence full-scale manufacture

3. (p. 109 and p. 230) alpha prototype – is produced to represent the aesthetic design and/or function of the final product, but not necessarily manufactured using identical processes or materials
beta prototype – a physical model that attempts to simulate the final design, aesthetics, materials and functionality of the intended product

4. (p. 109) final instructions in the form of drawings, diagrams and digital data about the product's form, dimensions, manufacturing processes, tolerances, materials and surface properties of each non-standard part and assembly; also information regarding the overall arrangement and the sourcing of standard and proprietary parts

5. (p. 111) In the design process the sharing of data and ideas between engineers and designers is known as **concurrent** design.

6. (p. 111) **c.** design for manufacture and assembly

7. (p. 114) The term used to describe engineered materials made from two or more components is **composites**.

8. (p. 114) a thermoset plastic, most commonly polyester resin, reinforced by fine strands of glass

9. (p. 115) an elastomer is a polymer – a large molecule composed of repeating structural units – with the property of elasticity, and comes in both natural and synthetic forms e.g. natural rubber, silicones, EPDM

10. (p. 116) soda lime glass
used for producing bottles, light bulbs and windows

11. (p. 118) carbon steel – strong, tough and easy to manufacture and recycle; also comparatively cheap
stainless steel might be used instead for outdoor applications because it is highly rust-resistant and has low ductility

12. (p. 120) strong, light and ductile

13. (p. 120) a protective coating
because it is a hygienic, easy-to-form metal, resistant to alkalis and acids

14. (p. 122) thermoplastics soften and melt upon heating, whereas thermosets harden when heated

15. (p. 122) alternative to glass
seen in applications such as lighting, aircraft windows and spectacle lenses

16. (p. 124) good mechanical properties, heat-resistant and impervious to water
applications – films, textiles and bottles

17. (p. 125) **b.** medium-density fibreboard

18. (p. 128) take something away, add something, cast something, form something, grow something

19. (p. 128) processes of cutting or removing material from a solid piece, such as boring, drilling, milling, shaping and turning

20. (pp. 129-131)
- die cutting – involves a formed sharpened block, known as a die-cutting tool, making a predetermined incision when pressure is exerted, or cutting or creasing a thin material

- water-jet cutting – technique employs a tool capable of slicing into metal and other solid materials, such as glass and stone, using a high-pressure jet of water, enabling very fine details to be cut
- laser cutting – involves cutting metals or other non-reflective materials using a high-powered computer-controlled laser
- etching – uses acid to cut into the unprotected parts of a metal surface to create a design in the material

21. (p. 132) **d.** welding
22. (p. 136) involves pouring a liquid material into a mould, which contains a hollow cavity of the desired shape; liquid is allowed to solidify and the solidified part, known as the cast, is then ejected or broken out of the mould
23. (p. 136) hollow forms
24. (p. 141) a metal-forming process in which molten metal is forced into a mould or cavity under pressure
ideal for complex shapes and produces an excellent surface and dimensionally accurate part
25. (p. 144) **Forming** covers a set of manufacturing processes that involve the manipulation of sheets, tubes and rods into predetermined forms.
bending, panel beating, stamping, thermoforming, plywood forming, steam bending, superforming, glass slumping
26. (p. 152)
    - plating – involves covering a conductive surface with a metal
    - spray painting – involves applying a layer of paint, ink or varnish by using a spray gun to atomize paint particles and spraying them through the air onto a surface
    - powder coating – involves coating metal parts with a fine thermoplastic powder that is heated until it melts and forms a protective durable layer over the part
    - subtractive processes – includes polishing, sanding and grinding components to achieve the desired surface finish
27. (p. 156) brand values – the essential guiding principles and rules of a brand
brand image – the look, feel and impression generated by a brand's logo, products, retail environments, advertising, marketing and customer service
28. (p. 165) product, place, price, promotion, people, process, physical environment

Discussion/essay questions

1. Discuss why the selection of materials for the manufacture of a product is important. What factors do you need to consider in this selection? Why does a designer need to be increasingly aware of the environmental aspects of manufacture? (p. 112)
2. Why do you think branding is important to companies and consumers? Consider why consumers are drawn to brands and how companies use brand identity. (pp. 156-159)

Chapter 5: Contemporary issues

1. (p. 169 and p. 251) the process of a product becoming obsolete and perceived by consumers as non-functional after a certain period of time or use in a way that is planned or designed by the manufacturer
    enables manufacturers to encourage sales of new products by creating an irrational desire for new products, despite there being substantial life in the old products
2. (p. 170) the design of objects that aid the sustainability of the systems in which they operate
3. (p. 170) environmental, financial and social sustainability
4. (pp. 173-174) helps in manufacture by saving costs and improving efficiency, enables easy maintenance of product and recycling at the end of the product's life
5. (p. 176) how product is produced, manufactured, transported, packaged, used and disposed of
6. (p. 181) because by using less quantity of material or lighter-weight materials helps lower transportation costs and environmental impact
7. (p. 184) aims to contribute to the betterment of all and to ensure abundance, diversity and health to future generations
8. (p. 186) The legal action by which an injured party seeks to recover damages from personal injury or property loss from the producer or seller of a product is known as **product liability**.
9. (p. 186) the manufacturer's design has created a concealed danger
    the manufacturer has failed to provide needed safety devices as part of the design of the product
    the design called for materials of inadequate strength or failed to comply with accepted standards
10. (p. 190) inclusive design is an approach to design that aims to ensure that products are usable by, and accessible to, as many members of society as reasonably possible, without the need for special adaptation or specialized design.
11. (p. 191)
    - equitable use – the design is useful and marketable to people with diverse abilities
    - flexibility in use – the design accommodates a wide range of individual preferences and abilities
    - simple and intuitive to use – use of the design is easy to understand, regardless of the user's experience, knowledge, language skills or current concentration level
    - perceptible information – the design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities
    - tolerance for error – the design minimizes hazards and the adverse consequences of accidental or unintended actions
    - low physical effort – the design can be used efficiently and comfortably and with a minimum of fatigue
    - size and space for approach and use – appropriate size and space is provided for approach, reach, manipulation and use regardless of user's body size, posture or mobility

12. (p. 192) sensory (vision and hearing), cognitive (thinking and communication), motor (locomotion, reach and stretch and dexterity)

13. (p. 193) ergonomics is the study of human anatomical, anthropometric, physiological and biomechanical characteristics as they relate to physical activity and usability designers commonly use such data and testing to evaluate the physical design of controls and displays, seating postures and health and safety

14. (p. 194) An **exclusion** audit is a technique used to evaluate different products by comparing the proportion of the population that will be unable to use them.

15. (pp. 196-197) visceral design refers primarily to the initial impact a product and its appearance has when a user first catches a glimpse of it on a shelf, on the road or on television, whereas behavioural design is about a product's look and feel and refers to the total experience of using a product

16. (pp. 199-200)
    - physio-pleasure – derived from the senses of touch, smell and taste
    - psycho-pleasure – derived from the emotional reactions engendered through the experience of using a product
    - socio-pleasure – derived from the relationship and status people get from a product, and the pleasure gained in interacting with other people through a product
    - ideo-pleasure – derived from entities such as books, art and music; appeal to the consumer's tastes

Discussion/essay questions

1. Discuss the impact of the emergence of environmentalism on product design and manufacture? Why is 'green' or 'sustainable' design so important today? (pp. 168-183)
2. What ethical issues do contemporary designers need to consider? Draw up your own list of ethical guidelines to help you when designing products. (pp. 184-189)

Chapter 6: Design education and beyond

1. (pp. 210-211)
   copyright – form of intellectual property that gives the creator of an original work 'exclusive rights' for a certain time period in relation to that work, including its publication, distribution and adaptation, after which time the work is said to enter the public domain
   trademarks – are words, logos, devices or other distinctive features that can be graphically represented (identified by the symbols ™ and ®); they are used by companies to clearly and legally distinguish their products from competitors
   patents – cover creations, such as unique mechanical devices, mechanisms and processes, and protect inventions

Discussion/essay question

1. Discuss why you think it is important for designers to formally protect their intellectual property? Consider the ways in which product designs can be protected today. (pp. 209-211)