TEACHER GUIDE

7th–9th Grade

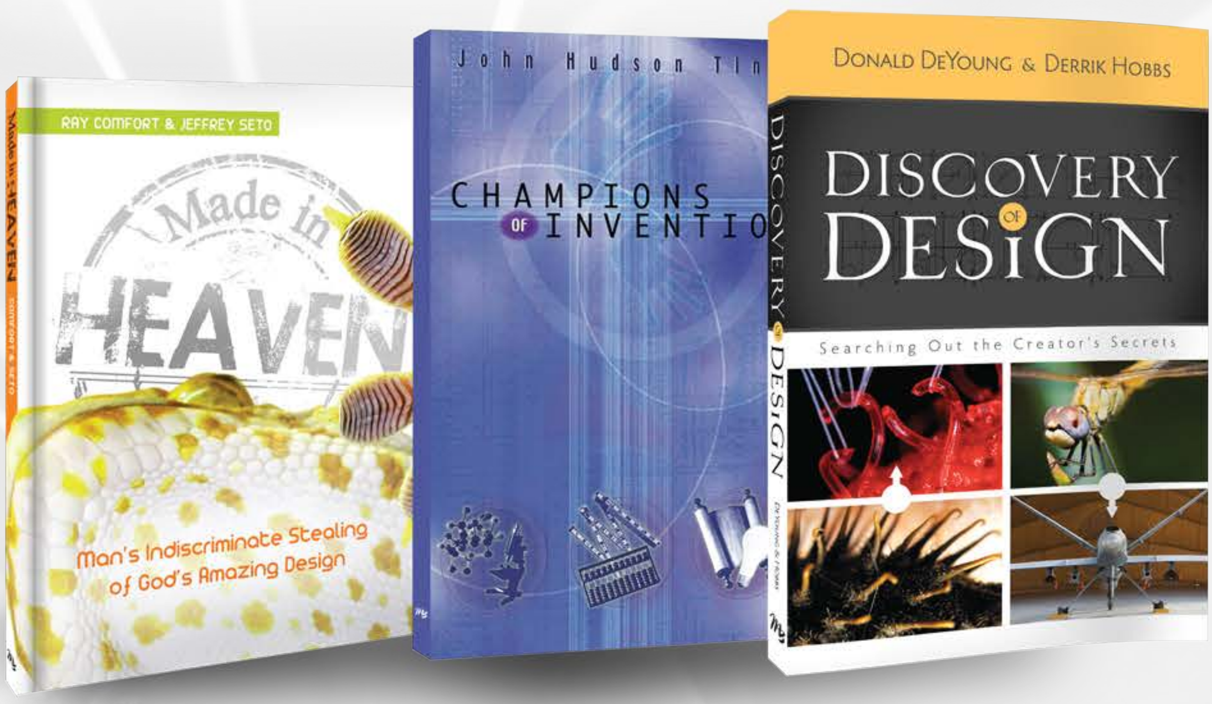
Includes Student Worksheets

Applied Science

- Answer Keys
- Weekly Lesson Schedule
- Worksheets
- Quizzes & Tests

APPLIED ENGINEERING

Studies of God's Design in Nature



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Applied Engineering: Studies of God's Design in Nature

MASTER BOOKS CURRICULUM

First printing: March 2014
Fifth printing: February 2017

For information write:

Master Books®, P.O. Box 726, Green Forest, AR 72638

Master Books® is a division of the New Leaf Publishing Group, Inc.

ISBN: 978-0-89051-989-9

Unless otherwise noted, Scripture quotations are from the New King James Version of the Bible.

Printed in the United States of America

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Don DeYoung is Chairman of the Science and Mathematics Department, Grace College, Winona Lake, Indiana.

Derrik Hobbs has an active interest in creation studies, including business models based on principles and processes found in nature.

Using This Teacher Guide

Features: The suggested weekly schedule enclosed has easy-to-manage lessons that guide the reading, worksheets, and all assessments. The pages of this guide are perforated and three-hole punched so materials are easy to tear out, hand out, grade, and store. Teachers are encouraged to adjust the schedule and materials needed in order to best work within their unique educational program.

Lesson Scheduling: Students are instructed to read the pages in their book and then complete the corresponding section provided by the teacher. Assessments that may include worksheets, activities, quizzes, and tests are given at regular intervals with space to record each grade. Space is provided on the weekly schedule for assignment dates, and flexibility in scheduling is encouraged. Teachers may adapt the scheduled days per each unique student situation. As the student completes each assignment, this can be marked with an "X" in the box.

	Approximately 30 to 45 minutes per lesson, four days a week
	Includes answer keys for worksheets, quizzes, and tests
	Worksheets for each section
	Quizzes and tests are included to help reinforce learning and provide assessment opportunities.
	Designed for grades 7 to 9 in a one-year course to earn 1 science credit
	Suggested labs (if applicable)

Course Objectives: Students completing this course will

- Evaluate how things like batteries, human organ repair, microlenses, automotive engineering, paint, and even credit card security all have links to natural designs
- Review how design in nature reveals the fingerprint of our Creator
- Discover how the glow of a cat's eyes innovates road reflectors
- Investigate the naturally sticky inspirations for Velcro® and barbed wire, as well as how a fly's ear, the lizard's foot, the moth's eye, and other natural examples are inspiring improvements and new technologies in our lives
- Study the life of the "forgotten" inventor, Joseph Henry, whose exploration of electricity set the standard for later innovators
- Identify how the exploration of practical intelligent design in nature offers a new paradigm for science inquiry.

Course Description

This *Applied Engineering: Studies of God's Design in Nature* teacher guide contains materials for use with *Made in Heaven, Champions of Invention*, and *Discovery of Design*. From the frontiers of scientific discovery, researchers are now taking design elements from the natural world and creating extraordinary breakthroughs that benefit our health, our quality of life, and our ability to communicate, and even help us work more efficiently. An exciting look at cutting-edge scientific advances, the course highlights incredible examples that include innovations like solar panels in space unfurled using technology gleaned from beech tree leaves, and optic research rooted in the photonic properties of opal gemstones.

Science continually borrows from God's creation, yet refuses to give God the glory. Engineers and inventors have long examined God's creation to understand and copy complex, proven mechanics of design in the science known as biomimicry. Much of this inspiration is increasingly drawn from amazing aspects of nature in search of wisdom and insight. We are surrounded daily by scientific advancements that have become everyday items, simply because man is copying from God's incredible creation.

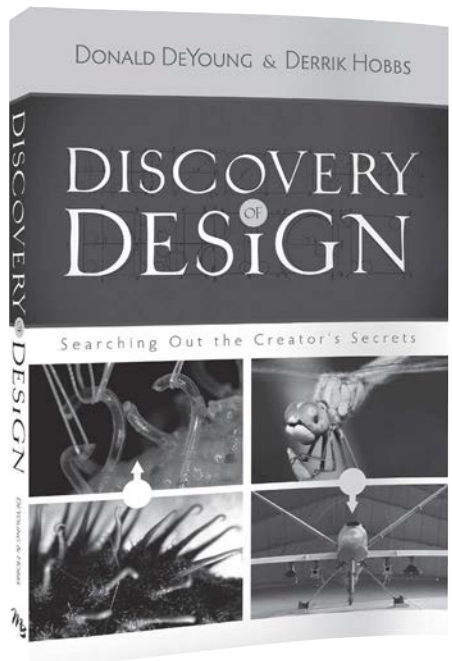
The great minds of the past are still with us today, in many ways. Individuals who explored the natural world hundreds and thousands of years ago have given us a treasure of knowledge in all the sciences. Short biographies of the world's most gifted thinkers will inspire the leaders of tomorrow. Find out how a personal tragedy paved the way for Samuel F.B. Morse to put aside his painting and develop the telegraph. These valuable learning guides will give students accurate accounts of lives from the halls of science, and explain what those scientists believed about the world around them. Here is a fantastic journey into the intersection of science and God's blueprints for life — discovering answers to some of the most intricate challenges we face and the scientists who laid the foundations for us based on God's creation.

Research Paper

Before the end of this course, a student is required to write a research paper on an inventor from *Champions of Invention*. One can begin reading the book and exploring the inventors in anticipation of this paper.

First Semester Suggested Daily Schedule

Date	Day	Assignment	Due Date	✓	Grade
		First Semester–First Quarter			
Week 1	Day 1	Introduction & Ch 1: Microorganisms: Bacteria-Micro-motor Read Pages 8–13, 188 (the appropriate answer section) *Discovery of Design* • (DoD) **Discovery of Design: Intro & Worksheet 1** • Pages 16–17 Teacher Guide • (TG)			
	Day 2	Ch 1: Bacteria-Battery • Read Pages 14–15, 189 • (DoD) **Discovery of Design: Worksheet 2** • Page 18 • (TG)			
	Day 3	Ch 1: Biofilm-Bacteria Control • Read Pages 16–17, 189 • (DoD) **Discovery of Design: Worksheet 3** • Page 19 • (TG)			
	Day 4	Ch 1: Diatom-Nanotechnology • Read Pages 18–19, 190 • (DoD) **Discovery of Design: Worksheet 4** • Page 20 • (TG)			
	Day 5				
Week 2	Day 6	Ch 1: Protien-Solar Cells • Read Pages 20–21, 190 • (DoD) **Discovery of Design: Worksheet 5** • Page 21 • (TG)			
	Day 7	Ch 2: The Insect World: Ants-Airlines Read Pages 23–25, 191 • (DoD) **Discovery of Design: Intro & Worksheet 1** • Pages 24–23 • (TG)			
	Day 8	Ch 2: Asian Beetle-Paper Whitener Read Pages 26–27, 191 • (DoD) **Discovery of Design: Worksheet 2** • Page 24 • (TG)			
	Day 9				
	Day 10				
Week 3	Day 11	Ch 2: Bombardier Beetle-Gas Turbine Engine Read Pages 28–29, 191 • (DoD) **Discovery of Design: Worksheet 3** • Page 25 • (TG)			
	Day 12	Ch 2: Butterfly-Cosmetics • Read Pages 30–31, 192 • (DoD) **Discovery of Design: Worksheet 4** • Page 26 • (TG)			
	Day 13	Ch 2: Dragonfly-Surveillance • Read Pages 32–33, 192 • (DoD) **Discovery of Design: Worksheet 5** • Page 27 • (TG)			
	Day 14	Ch 2: Firefly-Light Stick • Read Pages 34–35, 193 • (DoD) **Discovery of Design: Worksheet 6** • Page 28 • (TG)			
	Day 15				
Week 4	Day 16	Ch 2: Fly-Hearing Aid • Read Pages 36–37, 193 • (DoD) **Discovery of Design: Worksheet 7** • Page 29 • (TG)			
	Day 17	Ch 2: Honey Bee-Surveillance • Read Pages 38–39, 194 • (DoD) **Discovery of Design: Worksheet 8** • Page 30 • (TG)			
	Day 18	Ch 2: Insect Hearing-Atomic Force Microscope Read Pages 40–41, 194 • (DoD) **Discovery of Design: Worksheet 9** • Page 31 • (TG)			
	Day 19	Ch 2: Insects-Robotics • Read Pages 42–43, 195 • (DoD) **Discovery of Design: Worksheet 10** • Page 32 • (TG)			
	Day 20				



Applied Engineering Worksheets

for Use with

Discovery of Design

Introduction

1. What is the name of the science where designs are developed from designs in nature?

2. What are the two distinct explanations for the many successful ideas derived from studying nature?

3. What is the major flaw in crediting evolution for the successful design features found in nature?

4. What is the historic definition of science?

5. What are two reasons the Creator deliberately included all the useful design features in our world?

Bacteria > Micro-motor

1. What was the year of Leeuwenhoek's discovery of "small living creatures in rain water"?

2. How do many microscopic life forms propel themselves through liquids?

3. How many of these motors would fit along a one-inch length?

4. What are the three main parts of these "motors"?

5. Describe how myxobacteria move.

Digging Deeper

6. What is the precise meaning of the words *micro* and *nano*?

7. How does the speed of an electric fan compare with the 100,000-rpm rate of the molecular motor?

8. What are the chemical properties of silly string?

Bacteria > Battery

1. Why is *Rhodoferax ferrireducens* of special interest to scientists?

2. What is the efficiency rate for production of electric energy by *Rhodoferax ferrireducens*?

3. What are bacterial batteries?

4. What is the technological challenge toward making bacterial batteries a realistic option for energy-starved areas?

5. How much sugar would it take to power a 60-watt lightbulb for a number of hours using bacterial batteries?

Digging Deeper

6. What actually is a battery?

7. Why are most energy-conversion processes inefficient?

8. How many electrons pass through a standard 60-watt light bulb in one second?

Biofilm > Bacteria Control

1. What are biofilms?

2. How do members of biofilms communicate with one another?

3. What is the ability of biofilms to affect their surroundings by hundreds of chemical compounds called?

4. What is an example of biofilms helping to block invading foreign bacteria?

5. Studies are being done to determine if biofilms can control corrosion in what fuel-related equipment?

Digging Deeper

6. Estimate the number of bacteria on your hands.

7. Where might one find freshwater biofilms?

8. What are some unusual locations of biofilms?

Diatom > Nanotechnology

1. What are diatoms?

2. Where are diatoms found?

3. Why are scientists, who are interested in nanotechnology, looking at diatoms?

4. What two chemical substances are used to harden diatom components for use as microscopic mechanical gears?

5. What does the author mean by "designer diatoms"?

Digging Deeper

6. Are diatoms plants or animals?

7. What is the mineral name for glass?

8. Diatomaceous earth is a powdered form of diatom fossils. What are some of its uses?

Protein > Solar Cells

1. How do plants capture energy from the sun?

2. Which is more efficient at capturing energy from the sun – plants or silicon solar cells?

3. What part of plants have scientists succeeded in using to create small solar cells?

4. What happens when light shines on the plant-based proteins on an electricity-conducting glass surface?

5. What is one advantage for protein solar energy cells mentioned in the book?

Digging Deeper

6. How is electric current measured?

7. How is it possible that wind power, water power, and fossil fuels are all forms of solar energy?

8. Can you name three non-solar forms of energy?

Applied Engineering Worksheets

for Use with

Made in Heaven

Become a Champion of Invention!

You have completed enough coursework to have learned how many of today's most cutting-edge innovations are inspired by God's designs in nature. As you begin the remainder of this course, you will enjoy doing simple experiments and learn information on the science behind many of these innovations.

Now here is your challenge! Take steps to become an inventor:

1. Start an invention notebook, where you will detail your thoughts, and brainstorm ideas and do rough sketches.
2. Choose something related to nature that you find interesting.
3. Develop an idea for an improvement, innovation, or invention related to this natural design or feature of nature.
4. At the beginning, try to record as many of your thoughts as possible – even if they seem impractical. Try to list at least 8 to 10 ideas.
5. Next, look at your ideas, and see which ones are really needed and can be a practical help. This is where you narrow it down from the improbable to the practical. Try to list at least three of the most practical ideas. If needed, you can do simple drawings where you try to determine whether an idea is doable or not.
6. From these three ideas, choose the one you feel is most viable or able to be done. This is your proposed invention!
7. Now imagine what it would take for your idea to become a workable invention.
8. Create a plan for how you could possibly test out your idea in terms of making it an invention.
9. List three to five reasons for why your invention is needed.
10. Then present either a project notebook with a two-page presentation of your idea and your thoughts, or you can create a simple display on a poster.

Concepts and Definitions

The following information will lay a critical foundation for related Applied Learning activities. It is important that you read and understand this information so the Applied Learning opportunities can demonstrate and clarify important scientific concepts in action.

Fluid dynamics may sound like a science that is limited to fluid or water. But did you know that any object that moves through air or in water experiences the same aerodynamic effects and follows identical principles? It's true. Fluid does not mean liquids; rather any medium such as oil, air, gas, and various liquids that are subject to motion are classified as a "fluid." The only difference is the speed in which an object will travel.

This is due to different fluid densities. Density is defined as the mass (weight) per unit volume. As an example, if you had a gallon of water and a gallon of air, the gallon of water would be heavier. The density of water (62.4 lbs/ft^3) is much greater than the density of air (.08 lbs/ft^3).

The science of fluid dynamics is comprehensive and we will not be able to cover all that it entails. Rather, we will focus on the articles from the book *Made in Heaven* that are subject to the laws of fluid dynamics and the following characteristics of fluid flow over an object, which are covered in the book.

Boundary Layer

This is the thin layer that is adjacent to the surface of an object that is unaffected by either laminar or turbulent flow.

Laminar Flow

All fluid flow that moves over an object that takes on the appearance of smooth flow, parallel to the objects surface. Laminar flow contributes to speed, or flow, of an object. This is the opposite effect of turbulent flow.

Turbulent Flow

Turbulent flow is all fluid flow that moves in a rough/erratic flow pattern. This is the opposite effect of laminar flow.

Transition Point

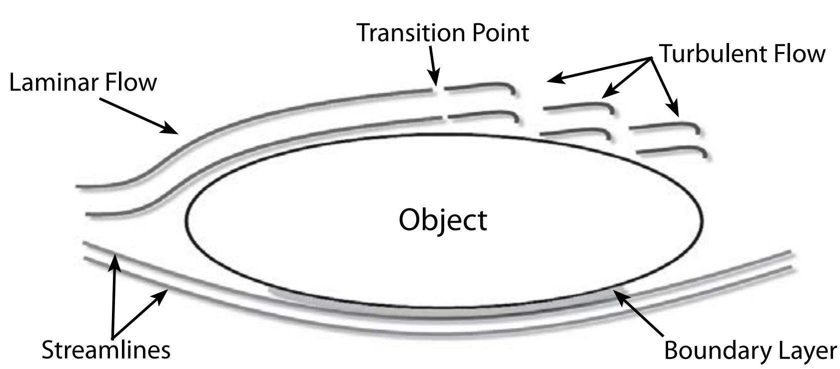
This is the location where the fluid flow transitions from laminar to turbulent flow.

Streamlines

This is a trace or an outline of the flow pattern around an object that defines the flow characteristics around the object.

Drag

Drag is exactly what it sounds like. Drag slows down and is a hindrance in the flow of fluid.



Q: Which flow type would you expect to exhibit drag?

A: If you said turbulent, then you are correct.

Rough flow = drag, and drag is caused by the shape of the object.

Applied Learning

The following activity or experiment illustrates important concepts for this portion of the coursework. Please make note of the scientific aspects of the activity as well as the specific areas of focus. These should reinforce important concepts and definitions that you have learned as you apply them.

Science

Fluid dynamics

Definition/Focus

Focusing on laminar and turbulent flow

Smooth flow is based on the shape of an object

Parts Lists

- Hand
- Large container of water, such as a pool or bathtub

Experiment

In the bathtub or a swimming pool, try to push the water with your hand in the following configurations:

1. An open palm with the fingers tightly pressed together
2. An open palm with your fingers spread apart (as far as you can)
3. Your hand balled up in a fist
4. With the edge of your hand (like a karate chop)

☑ **Take Away**

Note the difference in resistance felt by forming different shapes with your hand in the water. Different shapes exhibit different resistances. Fish are created with a shape that minimizes drag.

Questions:

1. Which shape moved the fastest in water?

2. Why do you think objects of that shape move faster?

3. Can you think of other types of shapes that move with speed?

4. What other examples in God's creation can you think of that might follow this principle?

Quizzes Section

Q	*Discovery of Design* / Concepts & Comprehension	Quiz 1	Scope: Chapters 1–2	Total score: ____of 100	Name

Answer Questions: (5 Points Each Question)

1. What is the name of the science where designs are developed from designs in nature?

2. How do many microscopic life forms propel themselves through liquids?

3. What are bacterial batteries?

4. What is an example of biofilms helping to block invading foreign bacteria?

5. What does the author mean by “designer diatoms”?

6. What happens when light shines on the plant-based proteins on an electricity-conducting glass surface?

7. Which insect is named in the Bible verse Exodus 10:4?

8. When it comes to ants, what determines the overall group behavior?

9. Where are several species of brilliant white beetles found?

10. What chemical does the bombardier beetle's spray and rocket fuel have in common?

11. What is the process called that cosmetic companies are using to mimic the light wave properties of butterfly and to replace the use of pigments, dyes, waxes, and oils?

12. What physical feature makes dragonflies unusual among insects?

13. What does a firefly create by mixing chemicals in its abdomen?

14. What is an additional potential benefit for hearing aids created by studying the fly?

15. How does light travel through the eye of a bee?

16. What do insects like grasshoppers or moths hear with their ultra-sensitive listening systems?

17. What is the major advantage of small, multi-leg robots over actual insects?

18. How does the beetle "drink" the water collected?

19. Why is synthetic spider silk one of the most sought after technologies in biomimicry?

20. Why are the termite mounds built by *Macrotermes michaelseni* of interest to architects?

21. What is another name for the chipper chain?

22. Why was paper so expensive centuries ago?

Bonus Questions: (10 Points Each Question)

1. How were big trees harvested before chainsaws were invented?

2. How do water striders move so rapidly on water?

Answer Keys

Introduction

1. Biomimicry
2. Millions of years of supposed evolutionary change developed these innovations; valuable, practical designs have been with since the beginning of time
3. Patterns and information are conserved with the passing of generations, but the DNA blueprint does not increase in complexity or gain new information.
4. The historic definition of science is the search for knowledge and truth about the physical world, wherever this may lead.
5. Design examples show us how to properly care for nature and maintain its health; the other purpose was for the benefit of living things, and also that ideas could be discovered and utilized for the welfare of mankind.

Chapter 1 – Worksheet 1

1. 1657
2. Using molecular motors
3. 10 million
4. flagellus, central shaft of protein, electrochemical reactions
5. This organism has hundreds of tiny nozzles covering its outer surface. It manufactures a slime that shoots from these nozzles, much like silly string. As a result, the bacterium recoils in the opposite direction using the principle of jet propulsion.
6. The prefixes micro and nano come from Greek roots meaning, respectively, "small" and "dwarf." Technically, micro stands for one millionth, or 10^{-6}. The, thickness of a sheet of paper is about 4000 micro-inches. A nano is defined as one billionth, or 10^{-9}. In one inch there are one million micro-inches, and one billion nano-inches.
7. Typical speed for a household electric fan is 1500 rpm. This is 60 times slower than the speed of the bacteria flagellum.
8. Silly string was first introduced as a child's toy in 1972. A liquid polymer in a pressurized aerosol container quickly turns solid when exposed to air. Polymers are compounds with long chains of chemically bonded molecules. One container can produce silly string hundreds of feet long.

Chapter 1 – Worksheet 2

1. This tiny microbe produces electrical current using simple sugars as its fuel source.
2. 80%
3. Energy-producing microorganisms
4. To combine the electric output from a large number of these bacteria to produce a practical level of current.
5. One cup
6. A battery is a chemical cell useful for storing electrical energy. Energy storage is a challenge for technology, and research continues on batteries with high efficiency and capacity.
7. When fuel is burned in a car to produce motion, much of the resulting heat energy is unused. This heat radiates outward from the engine and water coolant, and also leaves with the hot exhaust gases. The second law of thermodynamics describes such inevitable losses in every energy transfer process.
8. A light bulb, whether in a flashlight or reading lamp, has an electric current of about one ampere. This amounts to over six million-trillion electrons (actually 6.25×10^{18}) passing through the bulb filament each second. These electrons move through the filament at a snail's pace, somewhat similar to a large crowd passing through a narrow gate.

Chapter 1 – Worksheet 3

1. Large organized communities of bacteria
2. By releasing chemicals
3. Signal blocking
4. Protecting animals like dogs and cattle from cholera infection, or biofilms added to paint to prevent barnacles from attaching to the surface of boats

Made in Heaven — Worksheet Answer Keys

Chapter One

1. Number 4, the edge of your hand
2. The hand in this orientation simulates a wedge shape, which slices through the water. The other shapes have a larger frontal area, which cause more drag.
3. All shapes with rounded ends
4. Dolphins, squid, birds

Chapter Two

1. The corrugations and the popsicle sticks ran parallel with each other and provided no rigidity in the other direction.
2. Gluing down the second set of popsicle sticks 90 degrees to the corrugations provided the increase in strength.
3. There would still be additional strength added, as long as the second set of popsicle sticks do not run parallel with the cardboard corrugations.

Chapter Three

1. Able to break thread and paper, unable to break the remaining materials
2. Thread should have been the easiest
3. Fishing line, you were probably unable to break.
4. metal, wood, plastic

Chapter Four

1. Yes, after drying, the paper's shape changed and became wrinkled, resulting in the paper contracting.
2. Yes, the sponge did also shrink in size, but did not significantly change its shape as compared to the paper.
3. No, they did not. The sponge took more time to dry because of the larger size and the fact that it absorbed more water than the piece of paper.

Chapter Five

1. It would make no difference.
2. No, the only way is to physically glue it down.

Chapter Six

1. The only way is to make the air intake end stiffer to prevent it from moving all around. One method is to add tape around it a number of times to increase the thickness.
2. Less air in the balloon means less pressure, which will result in the balloon moving more slowly.
3. The farther away you stand, the more difficult it will be to hit the target. The closer you are, the better chance you have of directing the balloon through your friend's arms.

Chapter Seven

1. Violet, indigo, blue, green, yellow, orange, red
2. The rainbow will shift and/or disappear.

Chapter Eight

1. 360 degrees
2. A peak and trough
3. Since the peak of one wave will occur at the trough of the other wave, the net result is that they would cancel each other out in their entirety and result in a flat line.

Chapter Nine

1. Will be dependent on your camera, but your eyes will have a larger field of view than your camera. Some cameras have what is called a panoramic view setting which will provide you with a field of view far wider.

Chapter Ten

1. 27
2. Will vary from individual to individual
3. 4 x 4 x 4 x 4 = 1024
4. Thousands every day, which are variants of existing viruses

2. You will notice that the tunnel without the cardboard will collapse first.

Chapter Thirty

1. You could use anything that is shiny and has facetted surfaces. Shiny facetted-surface objects would work best.
2. Yes, you would have the same results as long as there was a reflected surface (plastic report cover). It would still work, regardless of the length of the can.
3. Mirrors, foil wrap, shiny metal surfaces

Chapter Thirty-One

1. Without sunlight there would be no photosynthesis process. No oxygen bubbles were produced in the dark.
2. Yes, the results were the same.

Chapter Thirty-Two

1. You will never see that.
2. You will notice leaves grow out from the center in a circular direction.
3. Yes they do — that is the main structural support that the leaf branches off from.

Made in Heaven Quiz Answer Keys

Quiz 1 – Chapter 1–8

1. resistances
2. drag
3. orientation, toughness
4. tension
5. thickness
6. strength
7. elasticity
8. tensile
9. temperature
10. metals
11. polymers
12. ceramics
13. semiconductors
14. material
15. material
16. pinecones
17. coarse
18. nanobots
19. magnetic
20. frequency
21. light
22. frequency
23. seven
24. peak
25. 360 degrees

Quiz 2 – Chapter 9–16

1. optics
2. reflected ray
3. refracted ray
4. reflected and refracted
5. Snell's
6. index
7. camera
8. mathematics
9. cognitive
10. thousands every day, which are variants of existing viruses
11. brain
12. small
13. neurons
14. For a whole brain we would need 42 x 10 = 420 semi-trailers.
15. sine
16. color
17. visible
18. ultraviolet

Made in Heaven Test Answer Key

1. drag
2. elasticity
3. pinecones
4. nanobots
5. seven
6. optics
7. camera
8. brain
9. chemistry
10. Ten times the length of the beetle. Example: if the beetle is 2" long, then the range would be 10 x 2 = 20".
11. fingertips
12. proteins
13. reflective
14. electromagnetism
15. drag
16. They need fans.
17. windshield wipers
18. sound
19. thermodynamics
20. You will notice leaves grow out from the center in a circular direction.