Answer Key

Teacher and parent copy: solutions, suggested times and materials for every unit, in order. Open answers (marked in the review pages) are scored out of 20 points per unit.

#	Unit
1	Earth, Moon & Sun
2	Rocky Planets
3	Giant Planets
4	Moons, Dwarf Planets & Small Bodies
5	Rockets, Orbits & Missions
6	Stars, Constellations & Galaxies
7	Life Beyond Earth
8	Astronaut Life

Teacher Notes

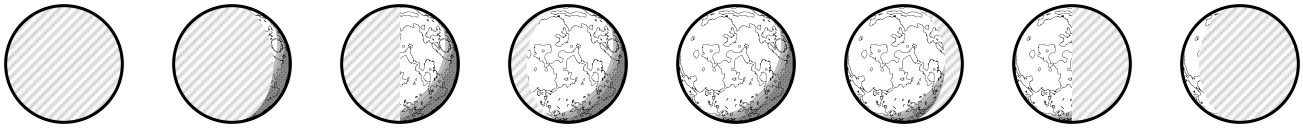
Unit 1 · Earth, Moon & Sun · Ages 9–14. Each page works on its own. Mix levels freely: ★ Explorer (ages 9–10), ★★ Navigator (11–12), ★★★ Commander (13–14). Figures are rounded; gravity is shown relative to Earth.

Page	Activity	Level	Time	Materials / notes
2	Think First & Briefing	★	20 min	KWL chart: revisit the last column at the end of the unit.
3	The Moon Goes Around	★★	25 min	Pencils; discuss why we always see the same face.
4	Moon Phase Memory Game	★	20 min + play	Scissors; two or more players.
5	Math Lab 1 · Time Zones	★★/★★★	30 min	Calculator for the last two items.
6	Seasons	★★	30 min	Ruler for the graph; connect points with a line.
7	Eclipse Detective	★★	30 min	Optional: flashlight and two balls. Never look at the Sun.
8	Word Search	★	15 min	Words also go backward.
9	Inside the Sun	★★/★★★	30 min	Calculator.
10	Tides	★★/★★★	30 min	Ruler for the bar graph.
11	Shadow Clock	★★	45 min + 6 hours sun	Sunny day; stick, clay, chalk, ruler, watch.
12	Moon Journal	★/★★	4 weeks, 5 min a night	Needs a clear evening sky; use a calendar to track dates.
13	Logic Lab	★/★★★	25 min	Pencil and calculator.
14	Create	★	30 min	Colored pencils, paper circles and string for the mobile.
15	Unit Review	★–★★★	25 min	Quiz out of 20 points.
16	Mission Log	★	10 min	Self-assessment.

Eclipse safety: never look at the Sun directly; use certified eclipse glasses. Tide times in the sample table are illustrative.

Pages 2–7

Page 3 · Moon phases



A New Moon · **B** Waxing Crescent · **C** First Quarter · **D** Waning Gibbous · **E** Full Moon · **F** Waning Gibbous · **G** Last Quarter · **H** Waning Crescent

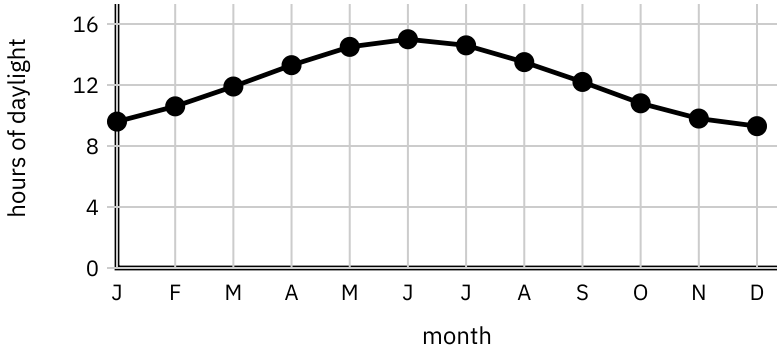
1. Letter **A** — **New Moon**. 2. **29½** days.

Page 5 · Time zones

1) **15°**; **90°**. 2) Chicago **2:00 PM**, Denver **1:00 PM**, Los Angeles **12:00 PM**. 3) **5:00 PM**. Clocks: 3:00 PM · 2:00 PM · 1:00 PM · 12:00 noon. 5) **12:30 PM**; **10:00 PM**. 4) 57 ÷ 15 = **3.8** → **about 4**. ★★★ 24,901 ÷ 24 = **1,038 mph**; 365 × 24 = **8,760**; 584,000,000 ÷ 8,760 = **66,667 mph**.

Page 6 · Seasons

1) Summer **C**; Winter **A**; Spring **B**; Fall **D**. 2) Most: **June**; least: **December**; 15.0 − 9.3 = **5.7 h**. 3) **Winter — Argentina is in the Southern Hemisphere, leaning away from the Sun in July**.

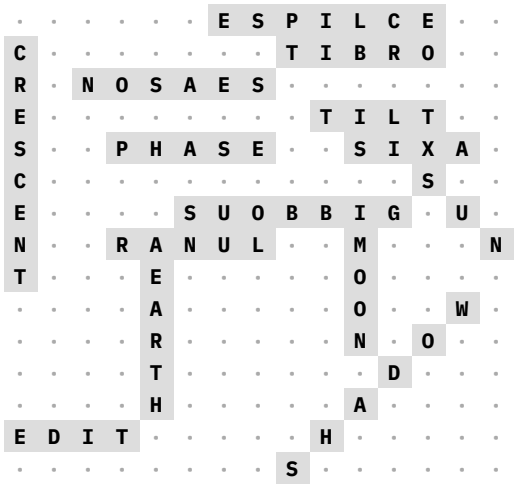


Page 7 · Eclipses

2) **New Moon**; **Full Moon**. 3) **The Moon's orbit is tilted about 5°, so the Moon's shadow usually misses Earth (and Earth's shadow misses the Moon).**

Pages 8–15

Page 8 · Word search



Page 9 · Inside the Sun

A **Corona**, B **Photosphere (surface)**, C **Convection zone**, D **Radiative zone**, E **Core**. 1) 864,000 ÷ 7,918 = **109.1**. 2) 93,000,000 ÷ 186,282 = **499 s** ≈ **8 min 19 s**. 3) 238,855 ÷ 186,282 = **1.3 s**. 4) **About 8 minutes 20 seconds — the last light is already on its way**.

5) 5,500 × 9 ÷ 5 + 32 = **9,932 °F**; 15,000,000 × 9 ÷ 5 + 32 = **27,000,032 °F** (about 27 million). 6) **333,000 lb**.

Page 10 · Tides

1) **12 h 25 min**. 2) 5.8 − 0.6 = **5.2 ft**. 3) 3:10 AM + 50 min = **4:00 AM**. Strong (spring) tides: New and Full Moon; weak (neap) tides: First and Last Quarter.

Page 13 · Logic

St	**Mo**	Su	**Ea**
Su	**Ea**	St	Mo
Mo	St	Ea	**Su**
Ea	Su	**Mo**	St

864,000 ÷ 2,159 = **400**; 93,000,000 ÷ 238,855 = **389** (both about 400). C) **Sun (makes its own light) · tide · phase · reflect**. Task 3: the Moon's apparent size will shrink as it recedes, so it will no longer cover the whole Sun.

Page 15 · Review (20 points)

1. New = all dark; First Quarter = right half lit; Full = all lit; Last Quarter = left half lit (4). 2. a **F — the tilt of the axis causes seasons**; b **T**; c **T** (3). 3. **8:00 AM**; **75°** (3). 4. 6.0 − 0.4 = **5.6 ft**; **about 4:25 PM** (3). 5. **The Sun makes its own light (nuclear fusion); the Moon reflects sunlight** (2). 8. rotate **B**, revolve **A**, umbra **C**, tide **D** (2). 6–7. Open answers, 2 points each, scored by reasoning. *(Without a tilt there would be almost no seasons.)*

Teacher Notes

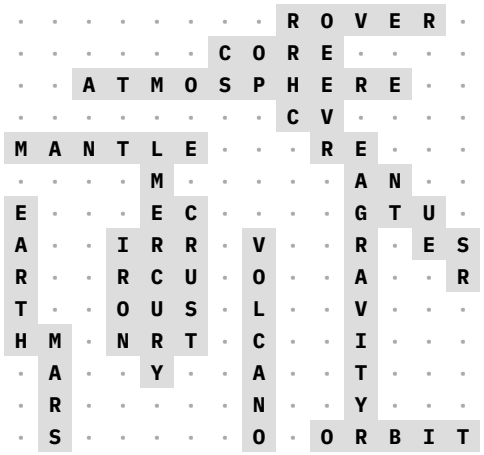
Unit 2 · Rocky Planets · Ages 9–14 · about 4–6 hours of activities. The unit is built so any single page works on its own. Mix levels freely: ★ Explorer (ages 9–10), ★★ Navigator (11–12), ★★★ Commander (13–14).

Page	Activity	Level	Time	Materials / notes
2	Mission Briefing	★	15 min	Read aloud or independently; students color the planets as they read.
3	Word Search	★	15 min	Bonus sentences are ★★.
4	Crossword	★★	20 min	Uses only unit vocabulary.
5	Scrambled & Missing Words	★/★★	25 min	Section C is ★★.
6	Math Lab 1 · Scale	★★ (★★★)	25 min	Ruler; print at 100% so the circles are true size. Calculator allowed.
7	Math Lab 2 · Weight & Jump	★★	25 min	Calculator allowed. Bar graph practice.
8	Math Lab 3 · Days, Years & Ages	★★★	30 min	Calculator. Division with decimals.
9	Hot, Cold & Inside Earth	★★★	30 min	Colored pencils; °F = °C × 9 ÷ 5 + 32.
10	Color by Number	★	25 min	Colored pencils: black, light orange, brown, white (leave blank), gray, yellow.
11	Maze & Sudoku	★/★★	20 min	Pencil.
12	Secret Messages	★★/★★★	25 min	Patterns and logic.
13	Compare & Contrast	★★	20 min	Scissors, glue (optional).
14	Trading Cards	★	20 min + play	Scissors; thick paper if you like.
15	Crater Lab	★★	40 min	Pan, flour, cocoa, 2 balls, ruler. Adult supervision for younger students.
16	Create	★	30 min	Crayons or colored pencils.
17	Unit Review	★–★★★	25 min	Use as a quiz; score out of 20 (see key).
18	Mission Log	★	10 min	Self-assessment.

Data notes: figures are rounded. Gravity is shown relative to Earth. Venus's day (243 Earth days) is its rotation period; Mercury's 176 days is sunrise to sunrise.

Pages 2–5 · Words

Page 3 · Word search solution



Page 4 · Crossword solution



Page 5 · Unscramble

1. MERCURY 2. VENUS 3. MARS 4. CRATER 5. ROVER 6. ORBIT 7. MANTLE 8. GRAVITY

Fill in the blanks: Venus, atmosphere, greenhouse, Red, rover, crater. Which planet am I? 1 **Mars** · 2 **Mercury** · 3 **Venus** · 4 **Earth**

Spot the mistake

1. Mercury is the smallest rocky planet. 2. Venus is the hottest; its thick atmosphere traps heat. 3. Mars has two tiny moons. 4. An Earth year is about 365 days (88 days is Mercury).

Pages 6–8 · Math Labs

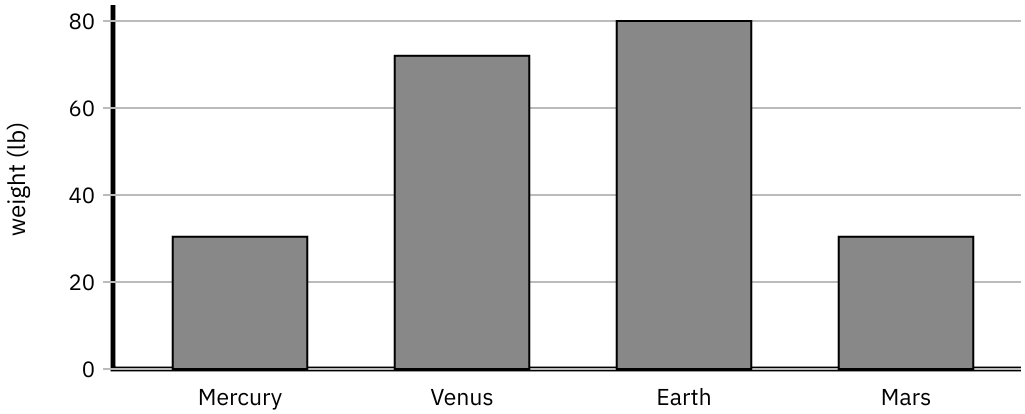
Math Lab 1 · Scale

Model widths: Mercury **0.6 in** · Venus **1.5 in** · Earth **1.6 in** · Mars **0.8 in**. (1) Largest: **Earth**; smallest: **Mercury**. (2) 7,918 − 3,032 = **4,886 miles**. (3) 7,918 ÷ 4,212 ≈ 1.9 → **about 2**. ★★★: 24,901 ÷ 60 = **415 hours** ≈ **17.3 days**.

Math Lab 2 · Weight & Jump (80 lb, 2 ft)

	Mercury	Venus	Earth	Mars
Weight (lb)	**30.4**	**72.0**	**80.0**	**30.4**
Jump (ft)	**5.3**	**2.2**	**2.0**	**5.3**

Graph: bars at 30.4, 72.0, 80.0, 30.4 lb. (1) 2,200 × 0.38 = **836 lb**. (2) 300 × 0.38 = **114 lb**. (3) **Mercury and Mars** (both 0.38 g). (4) 3 ÷ 0.38 = **7.9 ft**.



Math Lab 3 · Days, Years & Ages

(1) 365 ÷ 88 = **4.1**. (2) Age 12: Mercury **49.8**, Venus **19.5**, Earth **12**, Mars **6.4** (own age: multiply by 365 ÷ year). (3) 243 − 225 = **18 days**. (4) 176 ÷ 88 = **2 times**. (5) 33,900,000 ÷ 25,000 = **1,356 hours** ÷ 24 = **56.5 days**. (6) 687 ÷ 365 = **1.9 Earth years**. (7) Shortest: **Mercury**; longest: **Mars** (farther planets travel a longer path, more slowly).

Pages 9–13 · Science & Logic

Page 9 · Temperatures

Place	°C	°F
Mercury, daytime	430	**806 °F**
Mercury, nighttime	-180	**-292 °F**
Venus, surface	465	**869 °F**
Earth, average	15	**59 °F**
Mars, average	-63	**-81 °F**

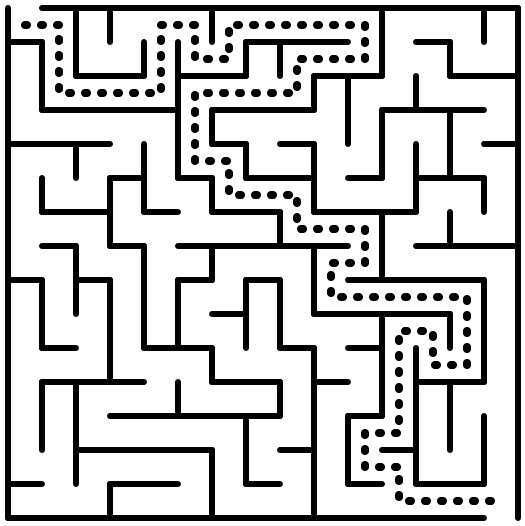
(1) 806 – (-292) = **1,098 °F**. (2) 869 – 59 = **810 °F**. **Inside Earth:** A **Inner core**, B **Outer core**, C **Mantle**, D **Crust**. ★★★ 20 + 1,800 + 1,400 + 760 = **3,980 mi**; difference from 3,959 = **21 mi**.

Page 10 · Color by number

9 – 8 = **1** Black · 12 ÷ 6 = **2** Light orange · 5 – 2 = **3** Brown · 2 × 2 = **4** White · 20 ÷ 4 = **5** Gray · 3 + 3 = **6** Yellow

1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	4	4	1	1	1	1	1	1	1	1	1
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1	1	1	1	1	1	6	1	1	1	1	6	1	1	1	1	1	1	1	1

Page 11 · Maze



Sudoku

Me	**Ve**	**Ma**	**Ea**
Ma	**Ea**	Me	**Ve**
Ea	**Ma**	Ve	**Me**
Ve	Me	**Ea**	**Ma**

Pages 12–18 · Codes, Compare & Review

Page 12 · Secret messages

A: **WATER ONCE FLOWED ON MARS** (shift 5). B: **THE ROVER FOUND ROCKS FROM AN ANCIENT RIVER** (shift 7).

Page 13 · Venn diagram

Letter	Fact	Where
A	Has polar ice caps	Both
B	Is a rocky planet	Both
C	Has seasons	Both
D	Has volcanoes (active or extinct)	Both
E	Has liquid water on its surface	Earth only
F	Has clouds in its atmosphere	Both
G	Has one large moon	Earth only
H	A day lasts about 24 hours	Both
I	Average temperature is far below freezing	Mars only
J	Only robots have visited so far	Mars only
K	Atmosphere is mostly nitrogen and oxygen	Earth only
L	Has two tiny moons	Mars only

Page 15 · Crater lab

Expected: higher drops and larger balls make wider craters and more splash rays. Mercury and the Moon keep their craters because they have almost no air, water or life to erase them; Earth's weather, water, plants and moving crust wear craters away.

Page 17 · Review (20 points)

1. Mercury **B**, Venus **D**, Earth **A**, Mars **C** (4). 2. **Mercury → Venus → Earth → Mars** (2). 3. a **T**; b **T**; c **F — craters are made by impacts**; d **F — Mars gravity is weaker, 0.38 g** (4). 4. **Jupiter — it is a gas giant, not rocky** (2). 5. **38 lb** (2). 6. **Thick carbon-dioxide atmosphere traps heat (greenhouse effect)** (2). 7. **Crust, mantle, core** (2). 8. Open answer: 2 facts + a reason (2 pts).

Pages 16 and 18 are open-ended: assess creativity and use of facts from the unit.

Teacher Notes

Unit 3 · Giant Planets · Ages 9–14. Each page works on its own. Mix levels freely: ★ Explorer (ages 9–10), ★★ Navigator (11–12), ★★★ Commander (13–14). Figures are rounded; gravity is shown relative to Earth.

Page	Activity	Level	Time	Materials / notes
2	Mission Briefing	★	15 min	Read aloud; color the Saturn picture.
3	Giants to Scale	★/★★	25 min	Ruler; print at 100% so the circles are true size.
4	Math Lab 1	★★/★★★	35 min	Calculator. Light travel time and wind bar graph.
5	Crossword	★★	20 min	No accents in puzzle words.
6	Saturn's Rings	★/★★★	30 min	Colored pencils. ★★★ item: ratio of width to thickness.
7	Logic Grid	★★/★★★	25 min	Pencil; solution is unique.
8	Moons of Jupiter cards	★	20 min + play	Scissors.
9	Math Lab 2	★★	30 min	Calculator; bar graph.
10	Gas vs Ice Giants	★★	20 min	Scissors, glue (optional).
11	Giant Planet Labs	★★	45 min	Tall glass, corn syrup or honey, dish soap, colored water, oil; paper strip, pencil, tape. Adult supervision for younger students.
12	Jupiter: Read, Color & Decide	★/★★	30 min	Colored pencils.
13	Board Game	★	30 min + play	Scissors, glue, coin tokens.
14	Create	★	30 min	Colored pencils.
15	Unit Review	★–★★★	25 min	Quiz out of 20 points.
16	Mission Log	★	10 min	Self-assessment.

Figures are rounded. Wind speeds are approximate maximums. The Great Red Spot has been shrinking in recent decades.

Pages 2–9

Page 3 · Scale

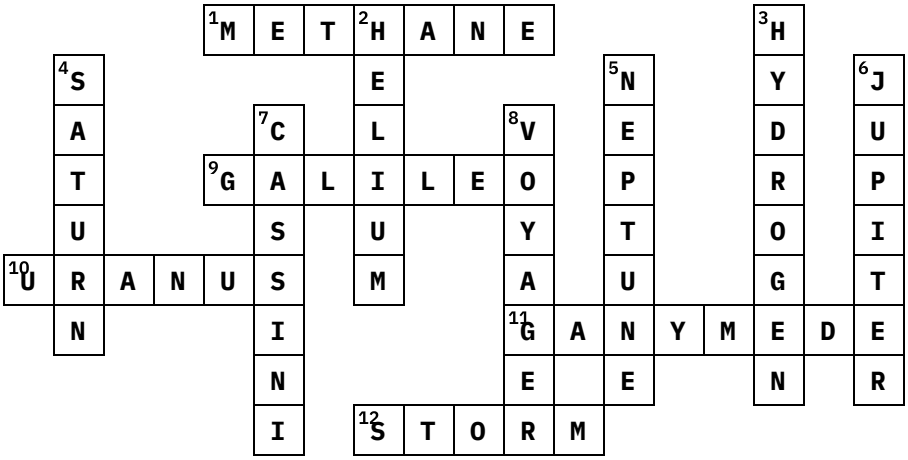
1) **3.5 in** ; **2.9 in** . 2) 86,881 ÷ 7,918 = **11.0** . 3) **Uranus and Neptune** .

Page 4 · Math Lab 1

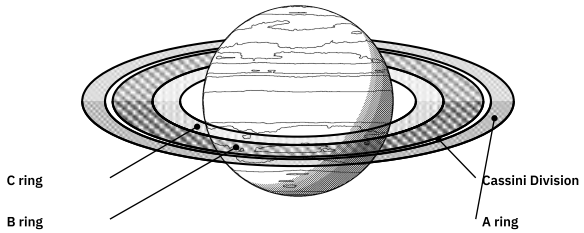
	Jupiter	Saturn	Uranus	Neptune
Earths wide	**11.0**	**9.1**	**4.0**	**3.9**
Sunlight (min)	**43 (43 min)**	**79 (1 h 19 min)**	**160 (2 h 40 min)**	**250 (4 h 10 min)**

1) 250 ÷ 8 = **31.3** . 2) **Neptune** ; 1,200 ÷ 160 = **7.5** . 3) 1,100 × 3 = **3,300** miles. ★★★ **318 lb** ; **95 lb** .

Page 5 · Crossword



Page 6 · Rings



A **C ring** , B **B ring** , C **Cassini Division** , D **A ring** . 1) 175,000 × 5,280 = **924,000,000 ft** . ★★★ 924,000,000 ÷ 30 = **30.8 million** ; 0.004 in × 30,800,000 = **123,200 in** ≈ **10,267 ft** (about 2 miles).

Pages 7–15

Page 7 · Logic grid

Ana: **Jupiter** · Ben: **Neptune** · Cara: **Saturn** · Dev: **Uranus**. Riddles: **Jupiter**, **Saturn**, **Neptune**.

Page 9 · Years & Ages

1) **165**; **2011**. 2) Jupiter **1.00** · Saturn **0.41** · Uranus **0.14** · Neptune **0.07**. 3) 24 ÷ 10 = **2.4**. 4) Fast spinning makes the equator move fastest, so it bulges outward.

Page 10 · Venn

Letter	Fact	Where
A	Includes the two biggest planets	Gas giants
B	Much bigger than Earth	Both
C	Has rings	Both
D	Has no solid surface	Both
E	Has many moons	Both
F	Made mostly of hydrogen and helium	Gas giants
G	Includes Uranus and Neptune	Ice giants
H	Methane gives it a blue-green color	Ice giants
I	Spins in less than 20 hours	Both
J	Contains lots of water, ammonia and methane	Ice giants

Page 11 · Labs

1) **syrup, soap, water, oil** (bottom to top). 2) **A dense core of rock and metal (scientists believe)**. B) 74,900 – 67,600 = **7,300 mi**.

Page 12 · Jupiter

T · **F** · **T** · **F**. 1) **Jupiter has no ground to slow the storm**.

Page 15 · Review (20 points)

1. **Gas: Jupiter, Saturn; Ice: Uranus, Neptune** (2). 2. J **D**, S **C**, U **B**, N **A** (4). 3. 2,793,000,000 ÷ 186,282 ÷ 60 = **250 min** (2). 4. **Galileo**, **1610** (2). 5. **F**, **T**, **F** — Saturn would float (3). 6. **Methane absorbs red light** (2). 7. Rings with a label (2). 8. **No: no solid surface** (3).

Teacher Notes

Unit 4 · Moons, Dwarf Planets & Small Bodies · Ages 9–14. Each page works on its own. Mix levels freely: ★ Explorer (ages 9–10), ★★ Navigator (11–12), ★★★ Commander (13–14). Figures are rounded; gravity is shown relative to Earth.

Page	Activity	Level	Time	Materials / notes
2	Field Guide	★	20 min	Read aloud; color the pictures.
3	Who Am I?	★	15 min	Pencil and ruler for the lines.
4	Sorting Hat	★★	25 min	Scissors, glue. ★★ item at the bottom.
5	Comet Lab	★/★★	30 min	Pencil; draw tails away from the Sun.
6	Word Search	★	15 min	Words go in six directions.
7	Math Lab 1	★★	30 min	Calculator.
8	Math Lab 2	★★★	35 min	Calculator; speed = distance ÷ time.
9	Asteroid Belt Maze	★★	25 min	Pencil.
10	Pluto	★★	30 min	Debate: allow students to disagree with evidence.
11	Cryovolcano	★★	40 min	Bottle, clay, baking soda, vinegar, food coloring, soap, tray. Adult supervision.
12	Bingo	★	25 min + play	Scissors, buttons or paper pieces.
13	Logic Lab	★★★	25 min	6×6 sudoku has one solution.
14	Create	★/★★	35 min	Colored pencils.
15	Unit Review	★–★★★	25 min	Quiz out of 20 points.
16	Mission Log	★	10 min	Self-assessment.

Figures are rounded. Gravity values: Moon 0.17, Io 0.18, Europa 0.13, Titan 0.14, Pluto 0.06, Ceres 0.03, Enceladus 0.01 (Earth = 1).

Pages 2–9

Page 3

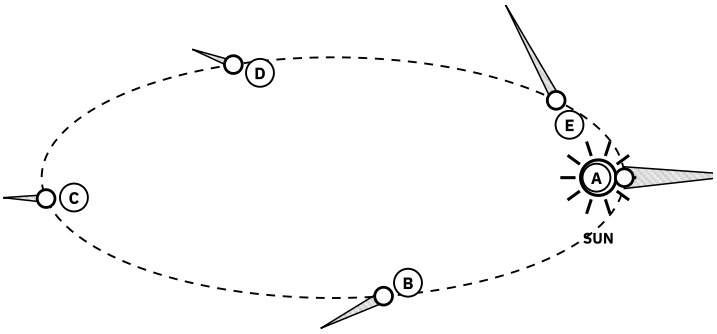
The Moon → **D** · Europa → **F** · Titan → **A** · Pluto → **B** · Ceres → **E** · Enceladus → **C**. ★ **"A world with an ocean" could fit Europa and Enceladus**.

Page 4

Earth **Planet** · Mars **Planet** · Pluto **Dwarf planet** · Ceres **Dwarf planet** · The Moon **Moon** · Titan **Moon** · Europa **Moon** · Enceladus **Moon** · Vesta **Asteroid** · Halley's Comet **Comet**. ★★ **It has not cleared its orbit: it shares the belt with many other objects**.

Page 5

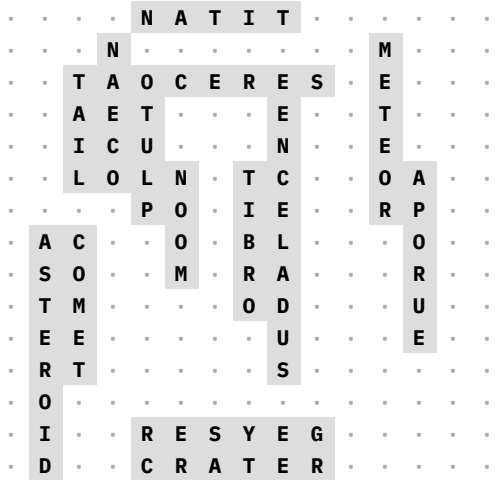
A **Nucleus**, B **Coma**, C **Dust tail**, D **Gas / ion tail**.



Tails always point away from the Sun; longest near the Sun.

1) **2061** (1986 + 75).

Page 6



Pages 7–15

Page 7 · Gravity

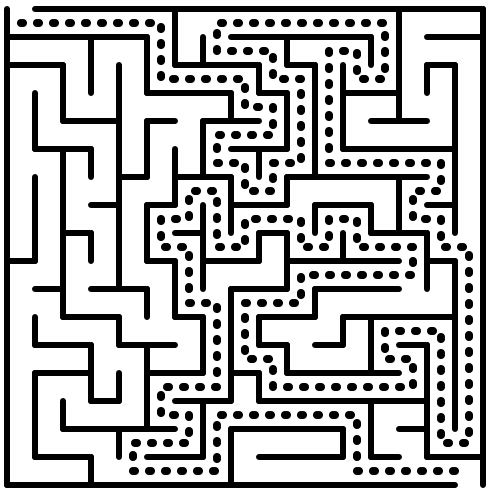
	The Moon	Io	Europa	Titan	Pluto	Ceres	Enceladus
Weight	**15.3**	**16.2**	**11.7**	**12.6**	**5.4**	**2.7**	**0.9**
Jump	**11.8**	**11.1**	**15.4**	**14.3**	**33.3**	**66.7**	**200.0**

1) **Enceladus**; **Io**. 2) **200.0 ft**; **you could leave the surface forever**. 3) 300 × 0.17 = **51 lb**.

Page 8 · New Horizons

1) **83,220** h. 2) 3,000,000,000 ÷ 83,220 = **36,049 mph**. 3) **65.5×**. 4) 3,000,000,000 ÷ 186,282 = **16,105 s** ≈ **4.5 h**. 5) **3,317 mph**. Pluto: 1930 + 248 = **2178** — **not yet: Pluto has not finished one orbit since its discovery**.

Page 9 · Maze



1) 3.2 − 2.2 = **1.0 AU** = **93,000,000 mi**.

Page 10 · Pluto

Earth: **yes · yes · yes → planet**; Pluto/Ceres: **yes · yes · no → dwarf planet**. 1) 751 ÷ 1,477 = **0.51** ≈ **one half**.

Pages 13–15

Page 13 · Sudoku

Pl	**Ti**	**Mo**	En	**Eu**	Ce
En	**Eu**	Ce	**Ti**	Mo	**Pl**
Ce	Pl	**En**	**Eu**	Ti	**Mo**
Ti	Mo	**Eu**	**Ce**	Pl	**En**
Mo	Ce	Ti	**Pl**	**En**	Eu
Eu	**En**	**Pl**	Mo	Ce	Ti

Titan / Titán · **Ceres** · **Europa**.

Page 15 · Review (20 points)

1. Dwarf planet: orbits the Sun, round, has not cleared its orbit. Comet: icy body with a tail near the Sun. (3). 2. Europa **C**, Titan **D**, Enceladus **A**, Pluto **B** (4). 3. **F** **F** **T** (3). 4. **13 lb** (2). 5. **2061** (2). 6–8. Open answers (2 points each).

Teacher Notes

Unit 5 · Rockets, Orbits & Missions · Ages 9–14. Each page works on its own. Mix levels freely: ★ Explorer (ages 9–10), ★★ Navigator (11–12), ★★★ Commander (13–14). Figures are rounded; gravity is shown relative to Earth.

Page	Activity	Level	Time	Materials / notes
2	Mission Briefing	★	15 min	Read aloud.
3	Rocket Anatomy	★/★★	25 min	Pencil. Stacking order is bottom to top.
4	Newton & Orbit Math	★★/★★★	35 min	Calculator.
5	Morse Code	★★	25 min	Pencil; optional tapping game.
6	Timeline	★/★★	25 min	Scissors, glue.
7	Spacecraft cards 1	★	20 min + play	Scissors.
8	Spacecraft cards 2	★	20 min + play	Scissors; blank cards for inventing spacecraft.
9	Rocket Numbers	★★/★★★	35 min	Calculator; plot the graph.
10	Straw Rocket Lab	★★	45 min	Paper, straws, tape, tape measure. Do outdoors.
11	Go / No-Go	★★★	25 min	The solution is unique.
12	Crossword	★★	20 min	No accents.
13	Launch Day	★	20 min	Scissors.
14	Create a Rover	★/★★	35 min	Colored pencils.
15	Unit Review	★–★★★	25 min	Quiz out of 20 points.
16	Mission Log	★	10 min	Self-assessment.

Figures are rounded. Dates and specifications are from NASA/ESA public sources.

Pages 2–9

Page 3

A–F: A **Launch abort system** · B **Orion capsule + service module** · C **Upper stage and adapter** · D **Core stage** · E **Solid rocket boosters** · F **RS-25 engines**. Stacking order: 1 **Solid rocket boosters** · 2 **Core stage** · 3 **RS-25 engines** · 4 **Launch vehicle stage adapter** · 5 **Upper stage (ICPS)** · 6 **European Service Module** · 7 **Orion crew capsule** · 8 **Launch abort system**. ★ **Launch abort system**.

Page 4

1) **The fastest path, a circle around Earth**. 2) **4,209 mi**; 2 × 3.14 × 4,209 = **26,446 mi**. 3) 26,446 ÷ 17,500 = **1.5 h** = **91 min**. 4) 24 ÷ 1.5 = **15.9** ≈ **16**. 5) **4.9 mi/s**.

Page 5 · Morse

1) **EARTH CALLING MARS** · 2) **ROVER LANDED SAFELY** · 3) **LIFTOFF IN TEN SECONDS**. SOS: **SOS**.

Page 6 · Timeline

1957 → **1961** → **1969** → **1977** → **1990** → **2000** → **2021** → **2022**. 1) **4**. 2) **53**; **Voyager (1977)**. 3) **26**.

Page 9 · Rocket numbers

1) 8,800,000 ÷ 5,750,000 = **1.5**; **1**. 2) 322 ÷ 100 = **3.2**. 3) 484 − 132 = **352 s**; 484 ÷ 60 = **8.1 min**. 4) **2,188 mph**. 5) 4 × 24 = **96 h**; 238,855 ÷ 96 = **2,488 mph**. 6) 25,000 ÷ 550 = **45**.

Pages 10–15

Pages 10–12

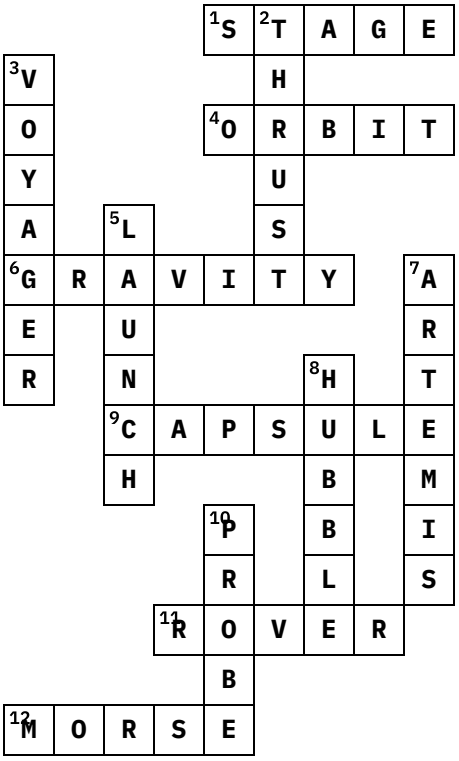
Page 10

Expected: 45° usually goes farthest. Repeating trials reduces random error.

Page 11 · Go / No-Go

Flight: **GO** · Guidance: **GO** · Propulsion: **NO-GO** · Weather: **NO-GO** · Range Safety: **GO** · Crew: **GO**. 1) **No — hold the launch**; **Propulsion**.

Page 12 · Crossword



Pages 13–15

Page 13 · Launch day

1. **The crew wakes up and eats breakfast.**
2. **The crew puts on their orange launch suits.**
3. **The crew rides to the launch pad.**
4. **The crew climbs into the Orion capsule.**
5. **Mission Control polls every station: Go or No-Go.**
6. **The countdown reaches T–10 seconds.**
7. **Boosters ignite: LIFTOFF!**
8. **The solid boosters separate (about 2 minutes up).**
9. **The core stage shuts down (about 8 minutes up).**
10. **Orion reaches orbit around Earth.**

1) **10**; **60**; **600**.

Page 15 · Review (20 points)

1. thrust **B**, orbit **D**, stage **A**, probe **C** (4). 2. **It moves sideways so fast that it keeps falling around Earth without hitting it** (2). 3. 1,440 ÷ 90 = **16** (2). 4. **SOS** (2). 5. **Sputnik → Apollo 11 → Hubble → Perseverance** (3). 6. **F** **T** **F** (3). 7–8. Open answers (2 points each).

Teacher Notes

Unit 6 · Stars, Constellations & Galaxies · Ages 9–14. Each page works on its own. Mix levels freely: ★ Explorer (ages 9–10), ★★ Navigator (11–12), ★★★ Commander (13–14). Figures are rounded; gravity is shown relative to Earth.

Page	Activity	Level	Time	Materials / notes
2	Mission Briefing	★	15 min	Read aloud.
3	Life of a Star	★/★★	30 min	Scissors, glue.
4	Connect the Dots	★	25 min	Pencil; red and blue pencils.
5	Light & Distance	★★/★★★	35 min	Calculator.
6	Star Colors	★★	30 min	Colored pencils.
7	Galaxy Zoo	★/★★	25 min	Pencil.
8	Word Search	★	20 min	No accents.
9	Memory Game	★	25 min + play	Scissors.
10	Star Chart	★★★	35 min	Pencil, ruler.
11	Code Breakers	★★	25 min	Pencil.
12	Pinhole Planetarium	★/★★	45 min	Tube or cup, pin, black paper, flashlight. Outdoors for hand measuring.
13	Create a Constellation	★/★★	30 min	Pencil.
14	Black Holes	★★/★★★	30 min	Reading.
15	Unit Review	★–★★★	25 min	Quiz out of 20 points.
16	Mission Log	★	10 min	Self-assessment.

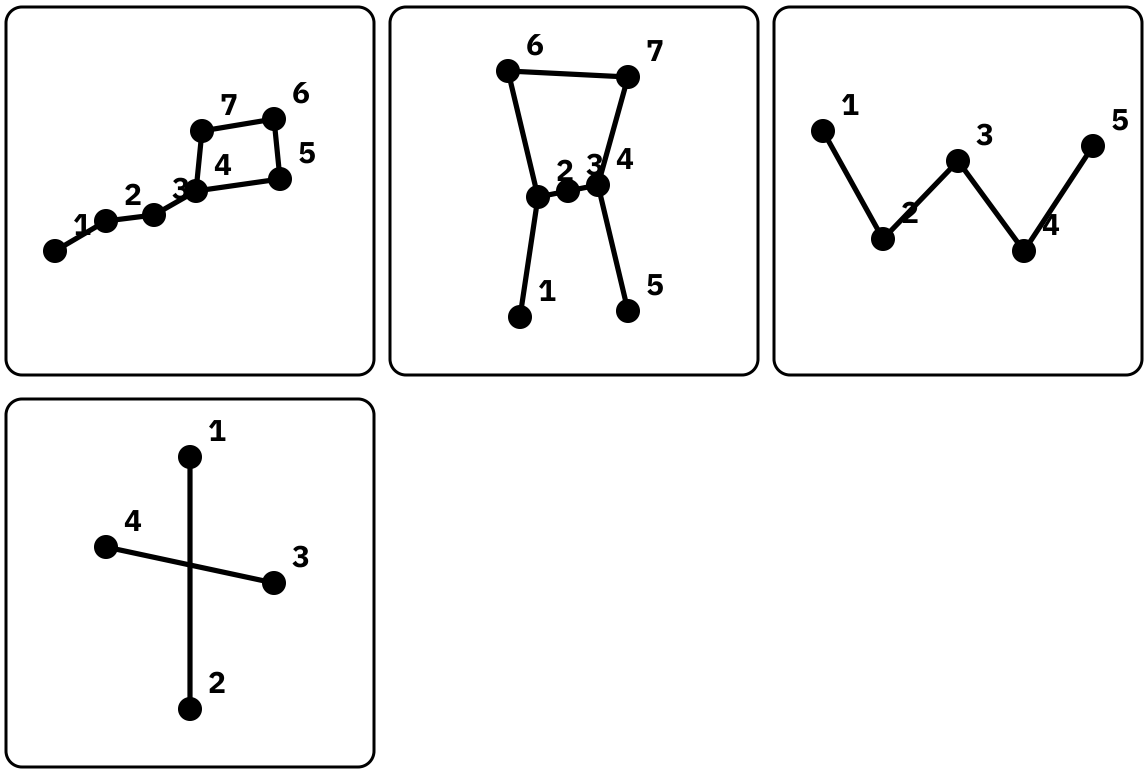
Distances are rounded. Light-year = 5.878 trillion miles.

Pages 2–7

Page 3

Path 1: 1. **A cloud of gas and dust (nebula)** · 2. **A protostar: the cloud collapses and heats up** · 3. **A main-sequence star burns hydrogen for billions of years** · 4. **A red giant swells up as hydrogen runs out** · 5. **A planetary nebula: the outer layers drift away** · 6. **A white dwarf: a hot, tiny core that slowly cools**
Path 2: 1. **A cloud of gas and dust (nebula)** · 2. **A protostar: the cloud collapses and heats up** · 3. **A massive star shines blue-white and burns fast** · 4. **A red supergiant swells to hundreds of times the Sun** · 5. **A supernova: the star explodes!** · 6. **A neutron star or a black hole is left behind**
1) **Nebula → protostar**. 2) **5.4**.

Page 4



Page 5

1) **499.2 s** (**8.3 min**). 2) **1.3 s**. 3) **8.6**; **age 2 (11 – 8.6 ≈ 2.4)**. 4) **24,922,720,000,000** miles ≈ **24.9**. 5) 24,922,720,000,000 ÷ 36,373 = **685,198,361** h; **78,165** years. 6) **3,127** generations. Number line order: **Sun, Proxima, Sirius, Vega, Betelgeuse**.

Page 6

Sun: **G** · Rigel: **B** · Betelgeuse: **M** · Sirius: **A** · Aldebaran: **K** · Proxima Centauri: **M** · Spica: **B** · Procyon: **F**. 2) **Cooler**.

Page 7

A: **Barred spiral** (**3**) · B: **Elliptical** (**1**) · C: **Irregular** (**4**) · D: **Spiral** (**2**). 2) **0.52** (**≈ ½**). 3) **4,545**.

Pages 8–11

Page 8 · Word search



Page 10 · Star chart

Brightness	O	B	A	F	G	K	M
Brilliant		● **Rigel**					● **Betelgeuse**
High		● **Spica**				● **Aldebaran**	
Medium			● **Altair**		● **Sun**		
Low							
Dim			● **Sirius B**				● **Proxima**

1) **Betelgeuse, Rigel (and Spica / Aldebaran): giants; Sirius B: white dwarf**. 2) **huge**; **small**.

Page 11 · Ciphers

1) **STARS ARE SUNS**. 2) **THE MILKY WAY HAS BILLIONS OF STARS**.

Pages 12–15

Pages 12–14

Open answers for pages 12 and 13. Page 14: 1) a T, b F, c T. 2) Not even light can escape it. 3) Examples: look at its effects, use special telescopes.

Page 15 · Review (20 points)

1. light-year C, constellation B, galaxy D, supernova A (4). 2. **blue, yellow, orange, red** (2). 3. **20** (2). 4. **STAR** (2). 5. **nebula, protostar, main sequence, red giant, white dwarf** (3). 6. **The Sun is a star** (3). 7–8. Open answers (2 points each).

Teacher Notes

Unit 7 · Life Beyond Earth · Ages 9–14. Each page works on its own. Mix levels freely: ★ Explorer (ages 9–10), ★★ Navigator (11–12), ★★★ Commander (13–14). Figures are rounded; gravity is shown relative to Earth.

Page	Activity	Level	Time	Materials / notes
2	Mission Briefing	★	15 min	Read aloud.
3	Goldilocks Zone	★/★★	30 min	Calculator.
4	Extremophile Cards	★	25 min + play	Scissors, colored pencils.
5	Create & Compare	★★	30 min	Pencil.
6	Transit Method	★★★	35 min	Pencil, calculator.
7	Color by Code	★/★★	30 min	Colored pencils.
8	Mission Planner	★★/★★★	25 min	The solution is unique.
9	Alive or Not?	★	25 min	Scissors, glue.
10	Salt Lab	★★	4 hours (check hourly)	3 cups, salt, freezer. Adult help with the freezer.
11	How Many Worlds?	★★/★★★	30 min	Calculator.
12	Crossword	★★	20 min	No accents.
13	Golden Record	★/★★	30 min	Discussion welcome.
14	Unit Review	★–★★★	25 min	Quiz out of 20 points.
15	Mission Log	★	10 min	Self-assessment.

No life has been found beyond Earth yet. The numbers on page 11 are guesses.

Pages 2–8

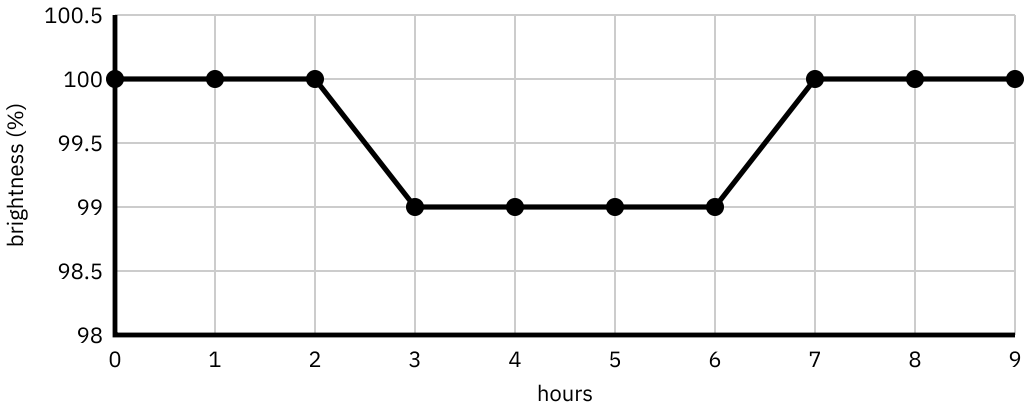
Page 3

2) **Earth and Mars (Mars at the cool edge)**. 3) 1.52 × 93,000,000 = **141,360,000** mi. 4) 0.05 × 93,000,000 = **4,650,000** mi; **Yes (0.05 < 0.39)**. 5) **Heat from tides (flexing) and geysers/hot cores keep water liquid**.

Page 5

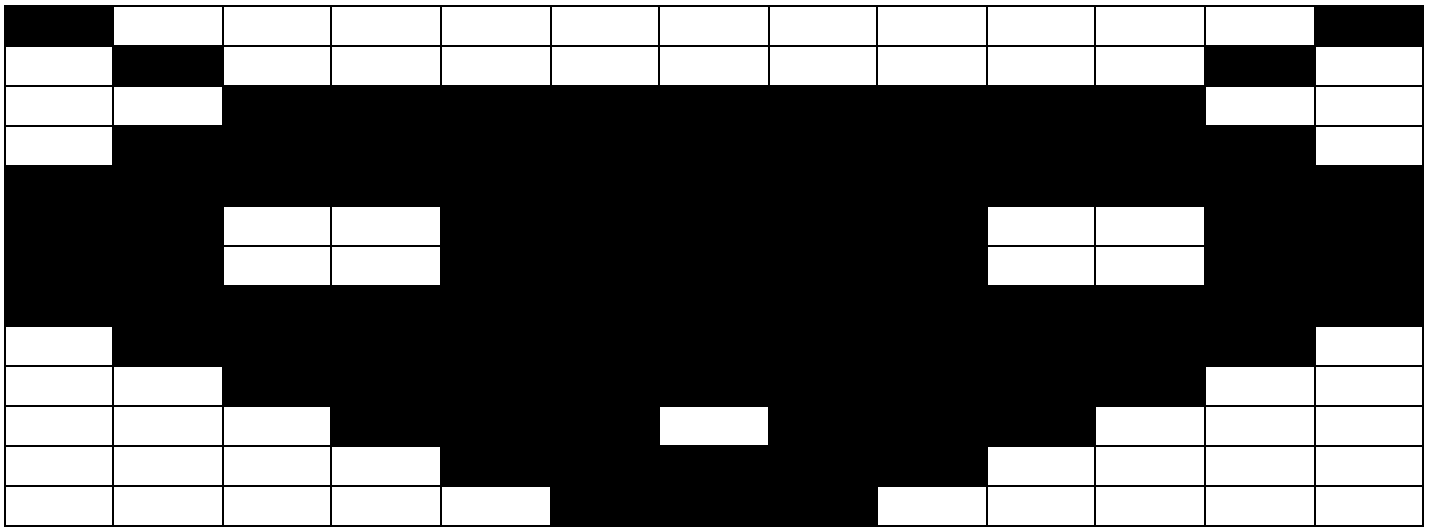
1) **Tardigrade (–458 °F to 300 °F)**. 3) 160 – 32 = **128**; × 5 ÷ 9 = **71** °C; 212 – 160 = **52** °F.

Page 6 · Transit



1) **4** hours (hour 3 to 7). 2) **1** %. 3) √0.01 = **0.1**; 0.1 × 432,000 = **43,200** mi. 4) **Jupiter**. 5) **10**.

Page 7 · Alien



1) **An alien face**. 2) **13**; **102**. 3) **25,000**.

Page 8 · Planner

Monday: **Mars** · Tuesday: **Europa** · Wednesday: **Enceladus** · Thursday: **Titan**. 1) **Enceladus**.

Pages 9–14

Page 9

Alive: **Dog, Mushroom, Seed, Bacteria, Oak tree** · Not alive: **Robot, Fire, Crystal, Mars rover, Cloud, Car** · Tricky: **Virus**. 1) **It has no cells and cannot reproduce on its own**.

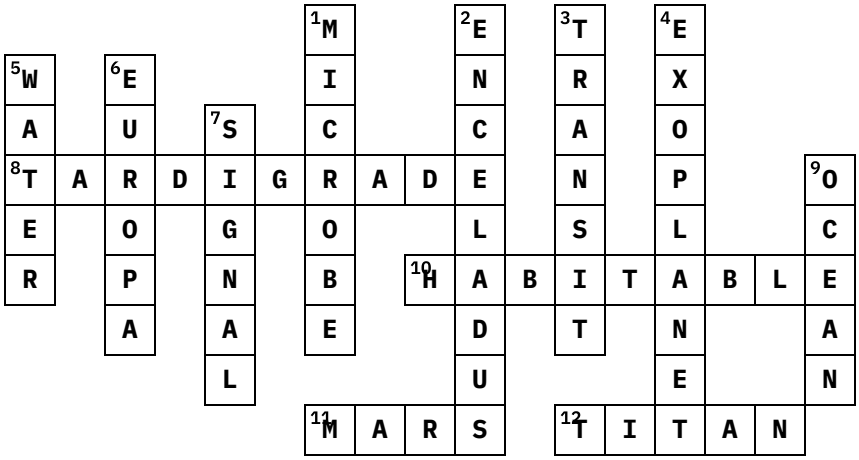
Page 10

Expected: A freezes first; C stays liquid longest (salt lowers the freezing point).

Page 11

50,000,000,000 → **10,000,000,000** → **10,000,000** → **10,000**. 1) **10,000,000**. 2) **10,000**. 4) 4.24 × 2 = **8.48**. 5) **100**.

Page 12 · Crossword



Page 14 · Review

1. habitable zone C, extremophile B, exoplanet A, transit D (4). 2. **Water, energy, building blocks, time (any three)** (2). 3. **F**, **T**, **F** (3). 4. **96** % (2). 5. **They survive extreme conditions, including space** (2). 6. **Earth, Mars, Europa, Enceladus** (3). 7–8. Open answers (2 points each).

Teacher Notes

Unit 8 · Astronaut Life · Ages 9–14. Each page works on its own. Mix levels freely: ★ Explorer (ages 9–10), ★★ Navigator (11–12), ★★★ Commander (13–14). Figures are rounded; gravity is shown relative to Earth.

Page	Activity	Level	Time	Materials / notes
2	Mission Briefing	★	15 min	Read aloud.
3	Label the Spacesuit	★/★★	20 min	Pencil.
4	A Day on the Station	★★	30 min	Colored pencils, calculator.
5	Weight on Other Worlds	★★/★★★	35 min	Calculator.
6	Pack the Food Box	★★/★★★	30 min	Calculator; several solutions exist.
7	Spacewalk Maze	★/★★	15 min	Pencil.
8	Word Scramble	★	20 min	Pencil.
9	Crew Sudoku	★/★★★	30 min	Pencil.
10	Bones in Space	★★/★★★	35 min	Pencil, ruler.
11	Scenario Cards	★	25 min + play	Scissors; play in a group.
12	Falling Water Lab	★★	30 min	Bottle, nail (adult), sink. Do over a sink or outdoors.
13	Reading: Spacewalk	★★	30 min	Reading comprehension.
14	Patch & Letter	★/★★	40 min	Colored pencils.
15	Unit Review	★–★★★	25 min	Quiz out of 20 points.
16	Mission Log	★	10 min	Self-assessment.

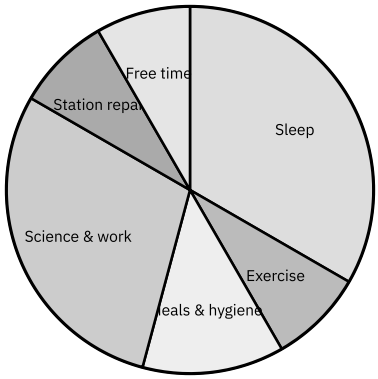
Weights shown are approximate; gravity values are relative to Earth. Bone loss is a simplified model.

Pages 2–6

Page 3

A **Helmet with a gold sun visor** · B **Life-support backpack** · C **Chest control panel** · D **Gloves with fingertip heaters** · E **Layers** · F **Boots**. Jobs: 1 → **D** · 2 → **A** · 3 → **F** · 4 → **C** · 5 → **B** · 6 → **E**.

Page 4



1) **24** hours; **15** °; Sleep **120°**, Exercise **30°**, Meals & hygiene **45°**, Science & work **105°**, Station repairs **30°**, Free time **30°**. 2) **33.3 %**; **29.2 %**. 3) 8 h = 480 min ÷ 90 = **5** (about 5).

Page 5

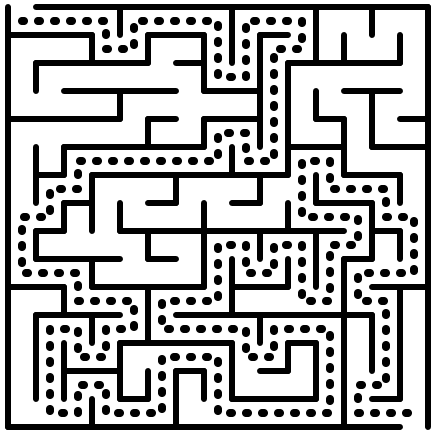
Moon: **26.4 lb** · Mercury: **60.8 lb** · Mars: **60.8 lb** · Venus: **145.6 lb** · Saturn: **171.2 lb** · Jupiter: **404.8 lb**. 1) **Moon**; **Jupiter**. 2) **49.5 lb**.

Page 6

One best solution: **Oatmeal pouch**, **Scrambled eggs**, **Tortilla**, **Peanut butter packet**, **Trail mix**, **Beef jerky**, **Chicken & rice**, **Mac & cheese**, **Granola bar** = **18.0 oz**, **2070 kcal**. 3) **166.7 cal/oz** → **Peanut butter packet**.

Pages 7–9

Page 7 · Maze



1) 119 × 4 × 2 = **952** s.

Page 8

1. **ASTRONAUT** · 2. **GRAVITY** · 3. **HELMET** · 4. **TETHER** · 5. **CAPSULE** · 6. **WEIGHTLESS** · 7. **EXERCISE** · 8. **STATION** · 9. **MISSION** · 10. **TRAINING**. Hidden word: **AGHTCWESMT**.

Page 9 · Sudoku

P	**H**	**B**	**G**
G	B	H	P
B	G	**P**	**H**
H	P	G	**B**

Sc	Pi	**En**	**Dr**	Co	**Ge**
Ge	Co	**Dr**	**Pi**	**Sc**	En
Pi	En	Sc	**Ge**	Dr	Co
Dr	Ge	**Co**	**Sc**	**En**	Pi
En	Sc	Ge	Co	Pi	**Dr**
Co	Dr	**Pi**	**En**	**Ge**	**Sc**

Pages 10–15

Page 10

0: **0 %** · 1: **1.2 %** · 2: **2.4 %** · 3: **3.6 %** · 4: **4.8 %** · 5: **6 %**. 3) **36 %**.

Page 11 · Scenario cards

1. **B** Put on masks, tell Mission Control and look for the source.
2. **B** Stay tethered and tell your crewmate and Mission Control.
3. **A** Move slowly, rest and tell the flight doctor.
4. **B** Follow the checklist and try the backup radio.
5. **B** Catch it with a towel or sip it with a straw.
6. **B** Zip into a sleeping bag fixed to the wall.
7. **B** Bones and muscles weaken: return to your 2 hours a day.
8. **B** Sit and let the recovery team help you: gravity is back!

Page 12

The stream stops (or nearly) while the bottle is falling. Explanation: both fall together, as an orbiting astronaut and the station do.

Page 13

1) **To remove nitrogen from the blood and avoid decompression problems**. 2) **To keep her from floating away**. 3) **390** min. 4) **113,750** mi. 5) **F** **T** **F**.

Page 15 · Review (20 points)

1. EVA C, microgravity D, tether A, airlock B (4). 2. **Because they are in free fall around Earth** (2). 3. **45.6** (2). 4. **To keep bones and muscles strong** (2). 5. **Put on the suit, breathe pure oxygen, check the seals, open the hatch** (3). 6. **B** (3). 7–8. Open answers (2 points each).

About the Field Guide

The Field Guide has no answers to check. The facts come from the simulator's catalog (NASA, ESA, JPL and USGS public data) and use US units. Use it for reference: kids can look up numbers needed in the math labs of Units 1–8.