3.5 Space Physics: 1-hour Pack

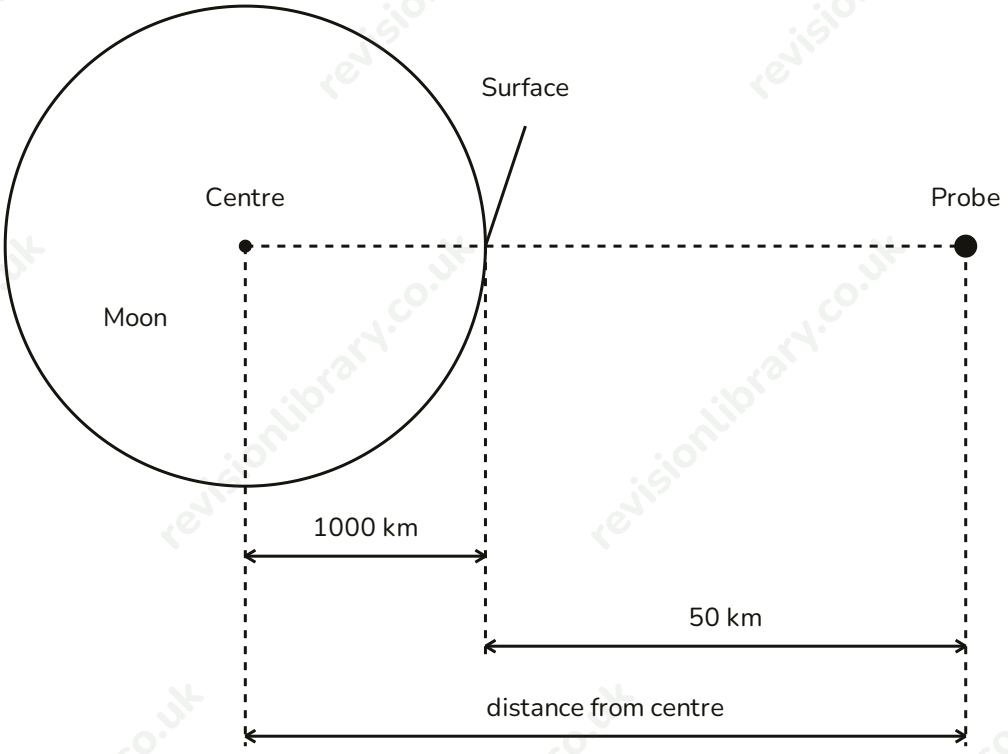
Calculator allowed · about 60 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 A probe orbits a small moon at height 50 km above the surface. The moon's radius is 1000 km and its mass produces a gravitational field strength at the surface of 0.5 N/kg. Assume g decreases with distance from the centre according to the inverse square law.

Diagram NOT accurately drawn



(a) Calculate the gravitational field strength at the probe (at distance from centre = radius + height). **(3)**

(b) Explain briefly why the probe weighs less at that height than on the surface. **(1)**

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2 State what keeps the Moon moving around the Earth instead of travelling off in a straight line.

(1)

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3 A student measures the brightness of a star each night over 10 nights. The brightness in arbitrary units is: 4.8, 4.9, 5.0, 4.7, 4.7, 4.8, 5.1, 5.0, 4.9, 4.8. The student thinks there is variation beyond measurement error.

(a) Calculate the mean brightness to two decimal places. **(2)**

(b) Suggest one reason, other than real change in the star, why the measurements might vary and one way to reduce this source of error in future observations. **(2)**

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4 Extended response (6 marks). A school must decide whether to invest time in training pupils to use a small telescope to observe planets or to buy a simple electronic light sensor to monitor variable stars. Evaluate both approaches and give a justified recommendation on which would be better for the school science club. You should consider factors such as cost, skills developed, data quality, accessibility and how the activity supports learning about space.

(6)

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5 Which of these correctly describes the shape of most planetary orbits in our Solar System? Options: A) Circular B) Elliptical C) Helix D) Parabolic

- [ ] A) Circular
- [ ] B) Elliptical
- [ ] C) Helix
- [ ] D) Parabolic

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6 A small model satellite is launched into a circular low Earth orbit at a height where the orbital speed is 7800 m/s. The satellite has a mass of 50 kg.

(a) Calculate the satellite's momentum in kg m/s. **(2)**

.....

(b) State how the momentum would change if the satellite's mass were doubled but speed stayed the same. **(1)**

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7 Describe one piece of evidence that supports the idea that Earth orbits the Sun rather than the Sun orbiting the Earth. Give the evidence and explain how that evidence supports the heliocentric model.

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.....

.....

(3)

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8 State the name for the region around a planet where its gravity is the dominant influence on satellites and objects.

(1)

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9 A newly discovered small asteroid orbits the Sun at an average distance of 1.2 astronomical units (AU). Using Earth as reference, where 1 AU = 150 000 000 km, calculate the asteroid's average orbital radius in kilometres. Give your answer in standard units (km).

(3)

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10 Describe why we see phases of the Moon (for example new moon, first quarter, full moon).

(2)

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11 Complete the sentences below using words from the box. Each word may be used once, more than once, or not at all.

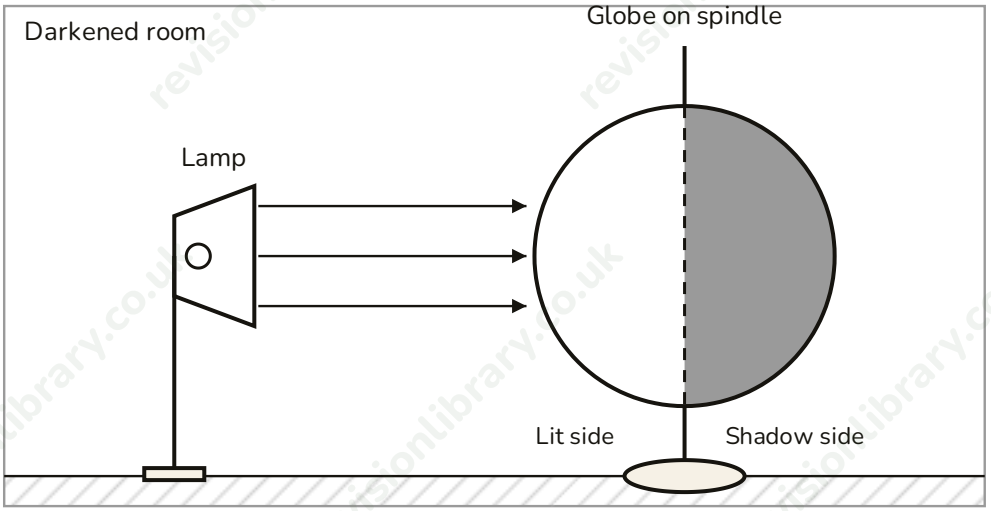
Word box: gravity, orbit, mass, weaker, stronger, weight

The Moon stays in _____ (i) around the Earth because of the force of _____ (ii) between the Earth and the Moon. The size of this force depends on the _____ (iii) of the two objects, and it gets _____ (iv) as the distance between the Earth and the Moon increases.

(4)

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12 A student models the Earth's day-night cycle using a lamp (representing the Sun) and a globe on a spindle (representing the Earth), in a darkened room.



(a) Identify which part of the model represents the Sun, and which part represents the Earth. **(1)**

(b) The student spins the globe on its spindle while the lamp stays still. Explain how this models day and night on Earth. **(2)**

(c) Suggest one way this model does not accurately represent the real Earth-Sun system. **(1)**

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13 Compare the life cycle of a star with a similar mass to the Sun with the life cycle of a star with a much greater mass than the Sun. Describe the key stages of each life cycle, and how each life cycle ends.

(6)

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14 The table shows the average distance from the Sun and the orbital period (time to orbit the Sun once) for the eight planets, measured in astronomical units (AU) and Earth years.
Planet: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune
Distance from Sun (AU): 0.39, 0.72, 1.00, 1.52, 5.20, 9.58, 19.2, 30.05
Orbital period (Earth years): 0.24, 0.62, 1.00, 1.88, 11.86, 29.4, 84.0, 164.8

Distance from the Sun and Orbital Period of the Planets

Planet	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune
Distance from Sun (AU)	0.39	0.72	1.00	1.52	5.20	9.58	19.2	30.05
Orbital period (Earth years)	0.24	0.62	1.00	1.88	11.86	29.4	84.0	164.8

(a) Describe the pattern shown by the data in the table between distance from the Sun and orbital period. **(2)**

(b) A dwarf planet orbits the Sun at an average distance of 40 AU. Using the pattern in the table, estimate its orbital period, and justify your estimate. **(3)**

15 A radio signal travels from Mars to Earth, a distance of 2.25×10^8 km, travelling at the speed of light, 3×10^8 m/s. Equation you may need: speed = distance / time.

(a) Convert the distance from Mars to Earth into metres. **(1)**

(b) Calculate the time taken, in seconds, for the radio signal to travel from Mars to Earth. **(2)**

(c) Convert your answer to part b) into minutes. **(1)**

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Mark scheme · 3.5 Space Physics: 1-hour Pack

Question 1

(a) use $g2 = g1 \times (r1/r2)^2$ with r1 = 1000 km and r2 = 1050 km — **M1**

(a) 0.454 N/kg cao — **A1**

(a) units N/kg or N per kg — **B1**

(a) Answer: **0.454 N/kg**

(b) weight depends on gravitational field strength which is smaller further from the centre, so weight decreases, oe — **B1**

(b) Answer: **Because gravitational field strength is smaller at greater distance from the centre, so the probe's weight is less.**

Question 2

Earth's gravity pulls the Moon so it stays in orbit (cao) — **B1**

Answer: **Earth's gravity pulls the Moon and keeps it in orbit around the Earth.**

Question 3

(a) sum values and divide by 10 — **M1**

(a) 4.87 cao — **A1**

(a) Answer: **4.87**

(b) give a plausible source of variation such as atmospheric conditions, instrument calibration, or observer technique (eg clouds, seeing) — **M1**

(b) give a method to reduce it such as observe on clearer nights, use same calibrated instrument, average more measurements, or use electronic detector — **A1**

(b) Answer: **Atmospheric conditions such as thin clouds can change measured brightness; reduce this by observing on clear nights or using the same calibrated electronic detector and averaging more readings.**

Question 4

Level 3 A balanced evaluation comparing both options with clear reasoned judgement. Discusses cost, skills, data quality, accessibility and learning outcomes and gives a justified recommendation with supporting points. — **5-6**

Level 2 Some comparison of the two options and includes a simple judgement. Mentions at least two relevant factors with some explanation. — **3-4**

Level 1 Limited or descriptive response. May list advantages or disadvantages of one option with little or no evaluation or justification. — **0-2**

Indicative content:

- Telescope option: develops observational and practical skills, good for direct engagement and learning about planetary appearance and motion, relatively low instrument cost but needs training and clear skies, data are qualitative or low-precision for science projects.
- Light sensor option: gives quantitative data suitable for analysis of variable stars, higher initial cost for sensor and interface, more inclusive as can be used indoors and in poor weather, supports data handling and scientific investigation skills.
- Comparison points: cost vs data quality, skills taught (visual observing and optics vs electronics and data analysis), accessibility (weather dependence), long-term educational value.
- Recommendation should weigh the school's priorities: for hands-on observing and engagement choose telescope; for reliable data collection and curriculum links to data analysis choose light sensor. A justified recommendation might be to buy a light sensor for reliable science projects and use occasional telescope nights for engagement.

Question 5

B cao — **B1**

Answer: **B) Elliptical**

Question 6

(a) use p = m v with m = 50 and v = 7800 — **M1**

(a) 390000 cao — **A1**

(a) Answer: **390000 kg m/s**

(b) momentum would double or state new momentum 780000 kg m/s — **B1**

(b) Answer: **The momentum would double to 780000 kg m/s.**

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Question 7

state a correct piece of evidence eg stellar parallax, phases of Venus, or retrograde motion explained by relative movement — **M1**

explain how that evidence shows Earth moves around the Sun (eg parallax shows viewpoint change over a year) — **A1**

link to heliocentric model conclusion (eg therefore Earth orbits the Sun not vice versa) — **A1**

Answer: **Stellar parallax: nearby stars shift position over a year as Earth moves, showing our viewpoint changes; this supports the heliocentric model that Earth orbits the Sun.**

Question 8

Hill sphere or sphere of influence cao — **B1**

Answer: **Hill sphere (also called the sphere of influence).**

Question 9

substitute 1.2 x 150000000 — **M1**

180000000 km cao — **A1**

correct unit km given — **B1**

Answer: **180000000 km**

Question 10

state that phases are due to changing portion of illuminated side visible from Earth as Moon orbits Earth — **M1**

mention relative positions of Sun, Earth and Moon causing different amounts of reflected sunlight seen (eg full Moon when Earth between Sun and Moon) — **A1**

Answer: **Phases occur because the Moon orbits Earth and we see different amounts of the side lit by the Sun; at full Moon we see the lit side, at new Moon the lit side faces away from Earth.**

Question 11

(i) orbit — **B1**

(ii) gravity — **B1**

(iii) mass — **B1**

(iv) weaker — **B1**

Answer: **(i) orbit (ii) gravity (iii) mass (iv) weaker**

Question 12

(a) lamp = Sun, globe = Earth (both needed) — **B1**

(a) Answer: **Lamp = Sun. Globe = Earth.**

(b) as the globe spins, the side facing the lamp is lit up, representing day (oe) — **B1**

(b) the side facing away from the lamp is in shadow, representing night, and this repeats as the globe keeps turning (oe, ft from part a) — **B1**

(b) Answer: **As the globe spins, the side facing the lamp is lit (day) and the side facing away is in shadow (night), repeating as the globe keeps turning.**

(c) any valid limitation, e.g. the model does not show the Earth's axial tilt, or the sizes and distances of the lamp and globe are not to the same scale as the Sun and Earth, or the globe does not also orbit the lamp (any one, oe) — **B1**

(c) Answer: **The model does not show the Earth's axial tilt (or the sizes/distances used are not to scale).**

Question 13

Level 1 Basic, mostly isolated statements about the life cycle of one type of star, with little or no comparison and limited use of scientific terms. — **1-2**

Level 2 Some relevant, mostly correct stages given for both types of star, with a partial comparison between them; scientific terms used with reasonable accuracy. — **3-4**

Level 3 A clear, correctly ordered and logically structured comparison of the life cycles of both types of star, explicitly comparing how each life cycle ends, using scientific terms accurately throughout. — **5-6**

Indicative content:

- Both types of star begin as a nebula (a cloud of dust and gas) that contracts under gravity to form a protostar, and then a stable main sequence star, fusing hydrogen into helium.
- A Sun-mass star spends most of its life as a stable main sequence star.
- When hydrogen fuel starts to run low, a Sun-mass star expands into a red giant.
- The red giant then loses its outer layers, leaving behind a small, dense white dwarf, which cools very slowly over a long time.
- A much more massive star also forms a main sequence star, but burns fuel faster and has a shorter overall lifetime than a Sun-mass star.
- A massive star expands into a red supergiant rather than a red giant.
- The red supergiant's core collapses suddenly, causing a supernova explosion.
- After the supernova, the remnant becomes a neutron star, or, for the most massive stars, a black hole, unlike the white dwarf left behind by a Sun-mass star.

Question 14

(a) as distance from the Sun increases, the orbital period also increases (oe) — **B1**

(a) the increase is not proportional; the orbital period increases much more quickly than the distance does (e.g. Neptune is about 77 times further out than Mercury, but its orbital period is about 690 times longer) (oe, accept any valid supporting comparison from the table) — **B1**

(a) Answer: **As distance from the Sun increases, orbital period increases, but much faster than in direct proportion.**

(b) identifies that 40 AU is a little further than Neptune's 30.05 AU (oe) — **M1**

(b) gives an estimate greater than Neptune's 164.8 years, e.g. in the range 190 to 260 years, with reasoning shown — **A1**

(b) justifies the estimate using the non-proportional trend identified in part a (period grows faster than distance), e.g. by extrapolating the increasing rate of growth, ft from part a — **A1**

(b) Answer: **Approximately 200 to 260 years (the true value, for the dwarf planet Pluto at 39.5 AU, is about 248 years); accept any reasoned estimate above 164.8 years that uses the trend from part a.**

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Question 15

(a) 2.25 x 10^{11} m cao **B1**

(a) Answer: **2.25 x 10^{11} m**

(b) correct substitution: time = 2.25 x 10^{11} / 3 x 10^{8} (ft from part a) **M1**

(b) 750 s cao **A1**

(b) Answer: **750 s**

(c) 12.5 minutes cao (ft from part b) **B1**

(c) Answer: **12.5 minutes**

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