3.5 Space Physics: 30-minute Pack

Calculator allowed · about 30 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 A planet orbits its star in a circular orbit of radius 2.0×10^8 km. Write down the relationship between orbital period, orbital circumference and orbital speed, then calculate the orbital speed if the period is 200 Earth days. Give your answer in km/s (1 day = 86400 s).

(3)

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2 A student tests models of communication delay between Earth and Mars. At one point Mars is 80 million km from Earth. Radio signals travel at the speed of light 300 000 km/s.

(a) Calculate the one-way time delay in minutes. **(2)**

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(b) Explain why missions must allow for this delay when sending commands. **(1)**

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3 Extended response (6 marks). Satellites in different orbits are used for weather imaging, GPS and deep-space astronomy. Discuss how the orbit height and orbital speed are chosen for these different uses, and evaluate the trade-offs engineers face when selecting an orbit. Use examples and refer to factors such as resolution, coverage, signal delay and launch cost.

(6)

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4 Complete the sentences about the Moon.

(a) The Moon orbits the Earth once in about ____ days. **(1)**

(b) One complete cycle of moon phases (new to new) is called a ____. **(1)**

(c) During a new moon the side of the Moon facing Earth receives ____ sunlight. **(1)**

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5 An experiment measures how temperature on a model 'planet' changes with distance from a lamp representing the Sun. The student records average temperature at four distances: 20 cm, 30 cm, 40 cm and 50 cm from the lamp. Data: distance (cm): 20, 30, 40, 50. temperature (°C): 60, 44, 33, 26. The student plots temperature (y axis) against distance (x axis).

(a) Plot the points on graph paper and draw a best-fit curve (description acceptable here). Describe the shape of the graph between 20 cm and 50 cm. **(2)**

(b) Calculate the temperature change between 20 cm and 30 cm and between 40 cm and 50 cm. Which interval shows the greater change? **(2)**

(c) Suggest one improvement to make this experiment a fair test and explain why it helps. **(1)**

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6 Give four points that explain why astronauts in orbit appear weightless even though Earth's gravity is still acting on them.

(4)

7 A space telescope slews to observe a distant galaxy. The control system must rotate the telescope with a constant angular speed of 0.2 degrees per second for a calibration test lasting 2 minutes. Calculate the total angle turned in that time and state whether the telescope has rotated more or less than one full circle.

(a) Calculate the total angle rotated in degrees. **(3)**

(b) Has the telescope rotated more or less than one full circle (360 degrees)? **(1)**

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Mark scheme · 3.5 Space Physics: 30-minute Pack

Question 1

state speed = distance / time and distance = circumference = 2 π r — **M1**

substitute r = 2.0 x 10^8 km and t = 200 x 86400 s and calculate — **M1**

answer 72.7 km/s (to 3 s.f.) cao — **A1**

Answer: **72.7 km/s**

Question 2

(a) time = distance / speed = 80 000 000 km / 300 000 km/s — **M1**

(a) 266.67 s -> 4.44 minutes cao — **A1**

(a) Answer: **4.44 minutes**

(b) because the delay means commands and telemetry take minutes, so real-time control is impossible and autonomy or pre-programmed sequences are needed, oe — **B1**

(b) Answer: **Because commands and responses take several minutes to travel, ground control cannot operate in real time, so missions need autonomous systems or pre-planned commands.**

Question 3

Level 3 Detailed explanation and evaluation. The answer explains how orbit height and speed affect resolution, coverage, and delay; gives specific examples (e.g. low Earth orbit for high-resolution imaging, geostationary for continuous weather cover, high orbits for astronomy), considers trade-offs including launch cost, signal delay and revisit time, and reaches a justified conclusion about selecting an orbit. — **5-6**

Level 2 Clear explanation with some evaluation. Covers two or three relevant factors and gives example(s) but with limited detail or justification. — **3-4**

Level 1 Basic statements about orbit height or speed with little linking to uses and few or no examples; evaluation missing or minimal. — **1-2**

Indicative content:

- Low Earth Orbit (LEO, a few hundred to 2000 km) gives high resolution and low signal delay; suitable for detailed imaging and some communications; disadvantage limited coverage and short revisit times.
- Geostationary orbit (~36 000 km) matches Earth's rotation so satellite stays over one point; good for continuous weather monitoring and some communications; disadvantage lower resolution for imaging and large signal delay.
- Medium Earth Orbit and specific orbits used for GPS trade coverage and revisit against cost; constellation design increases coverage.
- Deep-space or high orbits reduce atmosphere interference for astronomy but are expensive to reach and have long signal delays; stability and thermal environment also matter.
- Engineers trade higher launch cost and longer delays against coverage and resolution; mission goals determine the best compromise.

Question 4

(a) 27 or 27.3 or 28 days, accept 27-28 days, oe — **B1**

(a) Answer: **27 days**

(b) month or lunar month or synodic month, oe — **B1**

(b) Answer: **lunar month**

(c) no visible or little oe — **B1**

(c) Answer: **no visible**

Question 5

(a) description that the temperature falls as distance increases and curve is steep at small distances then shallows (inverse-square like) or similar — **M1**

(a) statement that curve is decreasing and becomes less steep as distance increases, oe — **A1**

(a) Answer: **Temperature decreases as distance increases; the curve is steep between 20 and 30 cm and becomes shallower between 30 and 50 cm.**

(b) calculate 60 - 44 = 16 and 33 - 26 = 7 — **M1**

(b) 16 degrees and 7 degrees, first interval greater cao — **A1**

(b) Answer: **20-30 cm: 16°C; 40-50 cm: 7°C; the 20-30 cm interval shows the greater change.**

(c) one clear improvement and reason, eg keep lamp brightness constant and use same lamp position so only distance changes, oe — **B1**

(c) Answer: **Keep the lamp brightness and orientation the same for every reading so only the distance changes, making the test fair.**

Question 6

they are in free fall/orbiting Earth so both astronaut and spacecraft fall together, oe — **B1**

there is no contact normal force from a surface on the astronauts, so they feel weightless, oe — **B1**

they have the same acceleration as their spacecraft so no relative force is felt, oe — **B1**

gravity is weaker but still present; weightlessness is due to free fall rather than absence of gravity, oe — **B1**

Answer: **Because they and the spacecraft are in free fall around Earth so they fall together; there is no contact force from a surface acting on them, so they feel weightless.**

Question 7

(a) angle = angular speed x time = 0.2 degrees/s x (2 x 60) s — **M1**

(a) substitute time 120 s and calculate angle = 0.2 x 120 = 24 — **M1**

(a) 24 degrees cao — **A1**

(a) Answer: **24 degrees**

(b) less than one full circle, since 24 < 360 — **B1**

(b) Answer: **Less than one full circle.**

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