

Solar system orbits and satellites

AQA GCSE Separate Physics 8463 only | Foundation and Higher | Paper 2

45 marks per path | 31 printed parts / 55 printed marks | Choose one replacement

Specification points covered

4.8.1.1: selected Solar System objects and the Milky Way galaxy
4.8.1.3: natural/artificial satellites, gravity and circular orbits; Higher ideas in Section 7
4.5.1.1: vector arrows; speed and velocity distinction in Higher Section 7
4.5.6.1.2: distance, time and average speed using supplied orbit data

A disaster-response agency needs flood images, storm updates and communications. Compare two model Earth-orbiting satellites, L and H.

Original PhysicsUK practice, not an official AQA resource. Common: 21 parts / 35 marks. Add either Foundation Section 6 (6 parts / 10 marks) or Higher Section 7 (4 parts / 10 marks). Each path is 45 marks. Timings estimated/untrials; no orbit-force equations required.

1 Checking the mission briefing

StormLink is a spacecraft built by people to orbit Earth. A briefing also mentions the Sun, Earth, the Moon, Pluto and the Milky Way. Pluto is classified as a dwarf planet.

1(a) State how many stars are in our Solar System and name the star. **[1 mark]**

Answer / mark points: One star: the Sun. [1 for both] The Milky Way contains many stars, but it is not the same thing as our Solar System.

1(b) The briefing puts the Moon and StormLink in a list of planets. Give the correct type of orbiting object for each. **[2 marks]**

Answer / mark points: The Moon is a natural satellite of Earth. [1] StormLink is an artificial satellite of Earth. [1] Neither is a planet just because it follows an orbit.

1(c) A trainee says the Solar System and the Milky Way are two names for the same collection of objects. Correct the statement. **[2 marks]**

Answer / mark points: Our Solar System is a small part of the Milky Way galaxy. [1] The galaxy contains many stars, whereas our Solar System is the Sun and the objects associated with/orbiting it. [1] Do not place the entire Milky Way inside our Solar System.

1(d) The trainee adds Pluto to the eight planets because Pluto orbits the Sun. Explain why this gives the wrong planet count. **[1 mark]**

Answer / mark points: Pluto is a dwarf planet, not one of the eight planets; orbiting the Sun alone does not make every object a planet. [1] No detailed planet-definition criteria are required.



2 Interpreting the system map

Figure 1 shows selected relationships, not physical positions or distances. Each arrow means “orbits”, not a force. The frames show membership of larger systems; many objects are omitted.

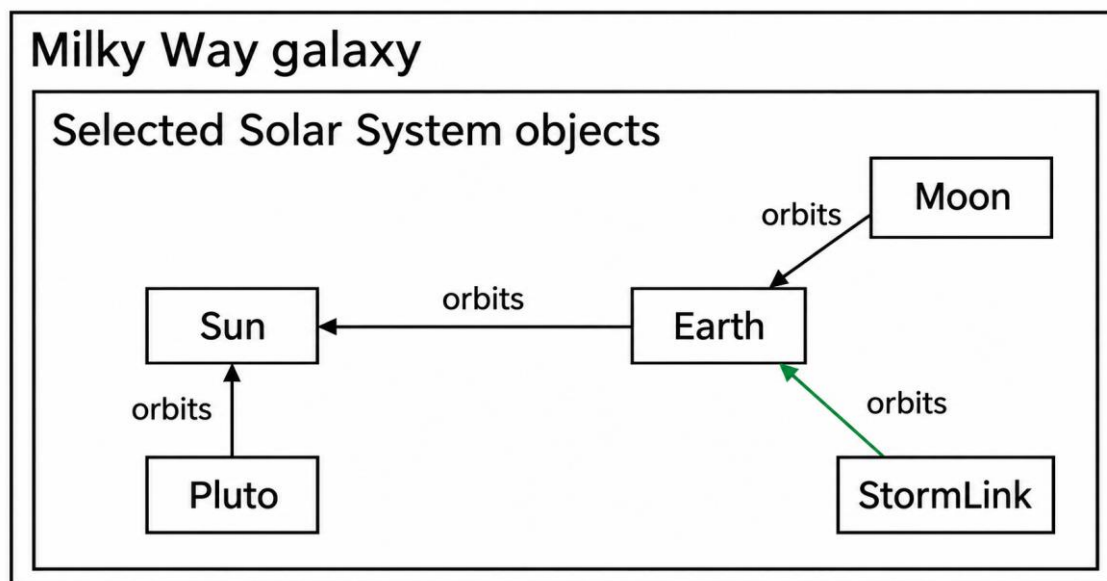


Figure 1

2(a) Use Figure 1 to identify the body StormLink directly orbits, rather than the body Earth itself orbits. **[1 mark]**

Answer / mark points: StormLink directly orbits Earth. [1] Earth in turn orbits the Sun; do not reverse the map's directed link.

2(b) Give one orbital similarity and one difference in origin between the Moon and StormLink. **[2 marks]**

Answer / mark points: Both are satellites orbiting Earth. [1] The Moon formed naturally, whereas StormLink was made/launched by people. [1] Merely saying that both are in space is insufficient.

2(c) Use the mapped orbits to explain the distinction between Earth as a planet and the Moon as a satellite. **[2 marks]**

Answer / mark points: Earth, the planet, orbits the Sun. [1] The Moon, the natural satellite, directly orbits the planet Earth. [1] The Moon is carried around the Sun with the Earth–Moon system, but that does not make it a planet.

2(d) Can the agency use Figure 1 to measure the Earth–Moon distance? Explain what the arrows actually tell the agency and what extra information is needed. **[2 marks]**

Answer / mark points: No: the diagram maps which object orbits which; its spacing/arrow lengths do not give a physical distance. [1] A numerical measured distance or an actual distance scale is needed. [1] These relationship arrows are not force vectors.



3 Calculating journey speeds

Table 1 contains rounded model data for settled circular Earth orbits. H has the larger orbital radius. Ignore air resistance. The length is the full path for one orbit, not height above Earth's surface.

Table 1

Satellite	Full orbit length / km	Time for one orbit
L	45 000	100 min
H	264 000	24 h

3(a) Convert L's time for one orbit into seconds. **[1 mark]**

Answer / mark points: $100 \times 60 = 6000$ s. [1]

3(b) Calculate L's average speed for one orbit in km/s. **[1 mark]**

Answer / mark points: Speed = orbit length / time = $45\,000 / 6000 = 7.5$ km s⁻¹. [1] Use the full orbit length, not an orbital height.

3(c) Express L's speed in m/s. **[1 mark]**

Answer / mark points: $7.5 \times 1000 = 7500$ m s⁻¹. [1] Allow consistent conversion of the pupil's answer to (b).

3(d) Calculate H's average orbital speed in km/s. Give your answer to two significant figures. **[2 marks]**

Answer / mark points: Time = $24 \times 3600 = 86\,400$ s. [1] Speed = $264\,000 / 86\,400 = 3.0555\dots$ km s⁻¹ ≈ 3.1 km s⁻¹ (2 s.f.). [1] Accept 3.06 km/s if rounding is the only issue; no separate extra mark is allocated just for rounding.

3(e) L begins a full orbit when a six-hour response shift starts. How many complete orbits can L finish during the shift? Show why the answer must be a whole number. **[3 marks]**

Answer / mark points: Six hours = 360 min, or 21 600 s. [1] Number of circuits = $360 / 100 = 3.6$. [1] Only 3 complete orbits are finished; the remaining 0.6 of an orbit is incomplete. [1] Do not round 3.6 up to 4.



4 Drawing the gravitational force

Figure 2 shows the same satellite at A and B at different times on one circular orbit. Earth is at the centre. Draw on this figure in 4(b); Higher pupils will return to it for 7(a). It is not to scale.

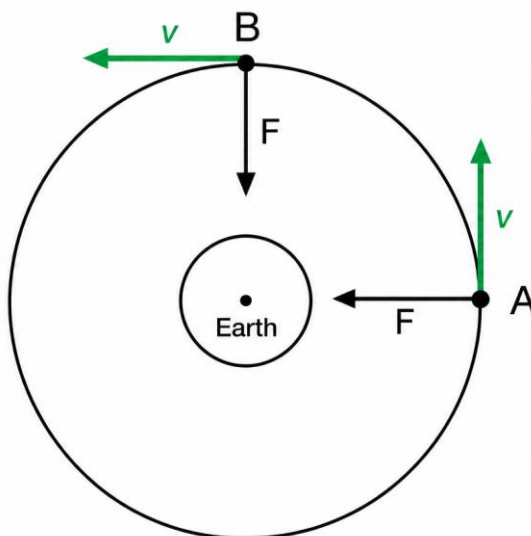


Figure 2

4(a) Identify the force that maintains the satellite's orbit and the body producing this force. **[1 mark]**

Answer / mark points: Earth's gravitational force on the satellite. [1 for force and source] No supporting cable or atmosphere is needed in this model.

4(b) On Figure 2 draw and label the gravitational force F at both A and B. Make the direction clear at each position. **[2 marks]**

Answer / mark points: A: arrow from the satellite towards Earth's centre, horizontally left. [1] B: arrow towards Earth's centre, vertically down. [1] Black F arrows in the teacher figure show this. Green v arrows are for Higher 7(a) only. No force magnitude/scale is required.

4(c) The Moon is natural rather than manufactured. Does it need a different kind of force to remain in orbit around Earth? State the force involved. **[1 mark]**

Answer / mark points: No: Earth's gravitational force also maintains the Moon's orbit. [1] The natural/artificial distinction concerns origin, not a different orbit-maintaining force.

4(d) A controller draws the gravitational force at A along the circular path and reads its drawn length as 500 N. Evaluate the direction and the claimed value. No force scale is given. **[2 marks]**

Answer / mark points: The direction is wrong: Earth attracts the satellite towards Earth's centre, not along the tangent to the path. [1] The value 500 N cannot be obtained from this unscaled drawing; a force scale or numerical force data would be needed. [1] Foundation pupils are not asked to explain changing velocity here.



5 Choosing satellites for real tasks

Table 2 gives supplied operational results for one target region. Smallest detail means the smallest ground feature distinguishable in a useful image: a smaller number gives finer detail. Do not infer these results from orbital period alone.

Table 2

Operational result	L	H
Smallest detail / m	20	1000
Longest useful-image gap / min	80	0 (continuous)
Ground-station contact	15 min windows	Continuous

5(a) A flood team needs images that distinguish 50 m features and can accept gaps of up to 90 min. Choose L or H, justifying your choice against both limits. **[2 marks]**

Answer / mark points: L resolves 20 m features, finer than the required 50 m. [1 for L and detail comparison] Its longest useful-image gap is 80 min, within the 90 min limit. [1] H's 1000 m detail fails the first requirement.

5(b) A storm team needs a useful image at least every 10 min, but 5000 m detail is adequate. Choose L or H and justify the choice using both requirements. **[2 marks]**

Answer / mark points: H's zero gap gives continuous useful views of this region, meeting the 10 min limit. [1 for H and gap comparison] Its 1000 m detail is finer than the required 5000 m. [1] L's 80 min gaps fail this timing requirement.

5(c) The agency wants a continuous relay link to a fixed ground station in this region. Which supplied option is better, and why is the other less suitable? **[2 marks]**

Answer / mark points: H is supplied as continuously visible from that station. [1] L has only 15 min contact windows, so its link is interrupted. [1] No recalled geostationary conditions are required; use the supplied operational evidence.

5(d) A manager claims L's faster orbital speed proves it must give more continuous useful views of the target than H. Evaluate this claim with the evidence. **[2 marks]**

Answer / mark points: The data contradict it: L has 80 min gaps, while H has zero gaps for the region. [1] Orbital speed/period is not the same as useful target coverage or revisit gap; these depend on the viewing arrangement, so a faster circuit alone is not enough. [1] Do not assume one orbit equals one uninterrupted view.



6 Foundation replacement

FOUNDATION PATH ONLY: complete this section instead of Section 7. Use the mission data and basic distance/speed/time calculations. No changing-velocity or stable-radius/speed explanation is required.

6(a) FOUNDATION REPLACEMENT. L moves at 7.5 km/s. How long does it take to travel 1500 km along its orbital path? **[1 mark]**

Answer / mark points: Time = distance / speed = $1500 / 7.5 = 200$ s. [1]

6(b) L's camera is off for 4.0 min. Calculate the distance L travels along its orbit while the camera is off. **[2 marks]**

Answer / mark points: 4.0 min = 240 s. [1] Distance = $7.5 \times 240 = 1800$ km. [1] Accept equivalent calculation using 450 km/min.

6(c) H takes 24 h for a full circular orbit. What path length does it cover in 12 h at its steady orbital speed? **[1 mark]**

Answer / mark points: Half the period gives half the orbit length: $264\,000 / 2 = 132\,000$ km. [1] This is path length, not straight-line separation.

6(d) For one test, assume L has exactly one 15 min contact window in each 100 min orbit. What percentage of an orbit allows contact, and why is this not a continuous link? **[2 marks]**

Answer / mark points: $15 / 100 \times 100 = 15\%$. [1] Contact is unavailable for the rest of the orbit (85 min), so a single L link is interrupted. [1] This percentage is time in contact, not a percentage of Earth's surface imaged.

6(e) A backup plan uses another artificial Earth satellite. Give the difference in origin from the Moon and identify the force that can keep either in Earth orbit. **[2 marks]**

Answer / mark points: The backup craft is made/launched by people; the Moon is natural. [1] Earth's gravitational attraction maintains either type of orbit. [1] No explanation of changing velocity is needed.

6(f) A new request needs both continuous useful views and 50 m detail. Can either single option in Table 2 meet both needs? Explain using both options. **[2 marks]**

Answer / mark points: No. L has sufficiently fine 20 m detail but 80 min viewing gaps. [1] H gives continuous views but its 1000 m detail cannot distinguish 50 m features. [1] Do not choose only by one requirement.

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7 Higher replacement

HIGHER TIER ONLY: complete this section instead of Section 6. The satellite in Figure 2 moves anticlockwise at constant speed. For 7(a), add velocity arrows to the same Figure 2 on page 4; keep them distinct from your force arrows.

7(a) HIGHER REPLACEMENT. On Figure 2 add velocity arrows at A and B for anticlockwise motion at constant speed. Use arrow length to represent speed and label each arrow v . **[3 marks]**

Answer / mark points: At A the tangent velocity points vertically up. [1] At B it points horizontally left. [1] The two v arrows have equal lengths to represent the same speed. [1] Green arrows show this. A radial arrow is a force direction, not the velocity direction.

7(b) Explain how Earth's gravity can change the satellite's velocity without changing its speed in this circular orbit. Include acceleration in the explanation. **[3 marks]**

Answer / mark points: Gravity produces a resultant inward force/acceleration towards Earth's centre. [1] This continually changes the direction of motion rather than increasing or decreasing the speed in the ideal circular orbit. [1] Velocity changes because it includes direction, although its magnitude (speed) stays constant. [1] Do not say that velocity is accelerating or that constant speed means no acceleration.

7(c) A design proposes a faster final stable circular orbit at the same radius, with an outward force balancing gravity. Identify and correct both errors. Do not calculate a new orbit. **[2 marks]**

Answer / mark points: For a different speed in a stable circular orbit around the same Earth, the orbital radius must change; it cannot simply remain the old radius. [1] Gravity supplies the inward resultant force, not a force cancelled by an outward balancing force. [1] This concerns final stable circular orbits, not the detailed powered transfer between them.

7(d) Use the L/H comparison to test "a larger stable circular orbit must have a higher speed". Does this evidence justify a rule that doubling orbital radius halves orbital speed? **[2 marks]**

Answer / mark points: No: H has the larger radius but a speed of about 3.1 km/s, below L's 7.5 km/s. [1] No exact doubling/halving rule follows; the supplied comparison does not establish that proportional relationship. [1] The GCSE qualitative relationship does not authorise an invented inverse-proportion calculation.

Review and improve

For Higher, distinguish speed (magnitude) from velocity (magnitude and direction). Gravity provides the inward resultant force; do not add an outward balancing force. Compare final stable circular orbits, not an instantaneous manoeuvre. Foundation needs only the common object/force-direction/data work and Section 6.

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