A LEVEL Cambridge Topical Past Papers

# PHYSICS

PAPER 4 2020 — 2025

1 - (9702/43_Summer_2023_Q1 ) ANSWER

**(a)** **(i)** Define gravitational field.

.....

..... [1]

**(ii)** Define electric field.

.....

..... [1]

**(iii)** State **one** similarity and **one** difference between the gravitational potential due to a point mass and the electric potential due to a point charge.

similarity: .....

.....

difference: .....

.....

[2]

**(b)** An isolated uniform conducting sphere has mass $M$ and charge $Q$.
The gravitational field strength at the surface of the sphere is $g$.
The electric field strength at the surface of the sphere is $E$.

**(i)** Show that

$$\frac{M}{Q} = \alpha \frac{g}{E}$$

where $\alpha$ is a constant.

[3]

**(ii)** Show that the numerical value of $\alpha$ is $1.35 \times 10^{20}\,\text{kg}^2\,\text{C}^{-2}$.

[1]

**(c)** Assume that the Earth is a uniform conducting sphere of mass $5.98 \times 10^{24}$ kg.
The surface of the Earth carries a charge of $-4.80 \times 10^{5}$ C that is evenly distributed.

**(i)** Use the information in **(b)** to determine the electric field strength at the surface of the Earth. Give a unit with your answer.

electric field strength = ..... unit ..... [2]

**(ii)** State how the direction of the electric field at the surface of the Earth compares with the direction of the gravitational field.

..... [1]

[Total: 11]

2 - (9702/42_Summer_2025_Q1) ANSWER

**(a)** Define the radian.

.....

..... [1]

**(b)** The rear wheel and the pedals of a bicycle are connected by a chain that passes around two cogs (toothed wheels), as shown in Fig. 1.1.

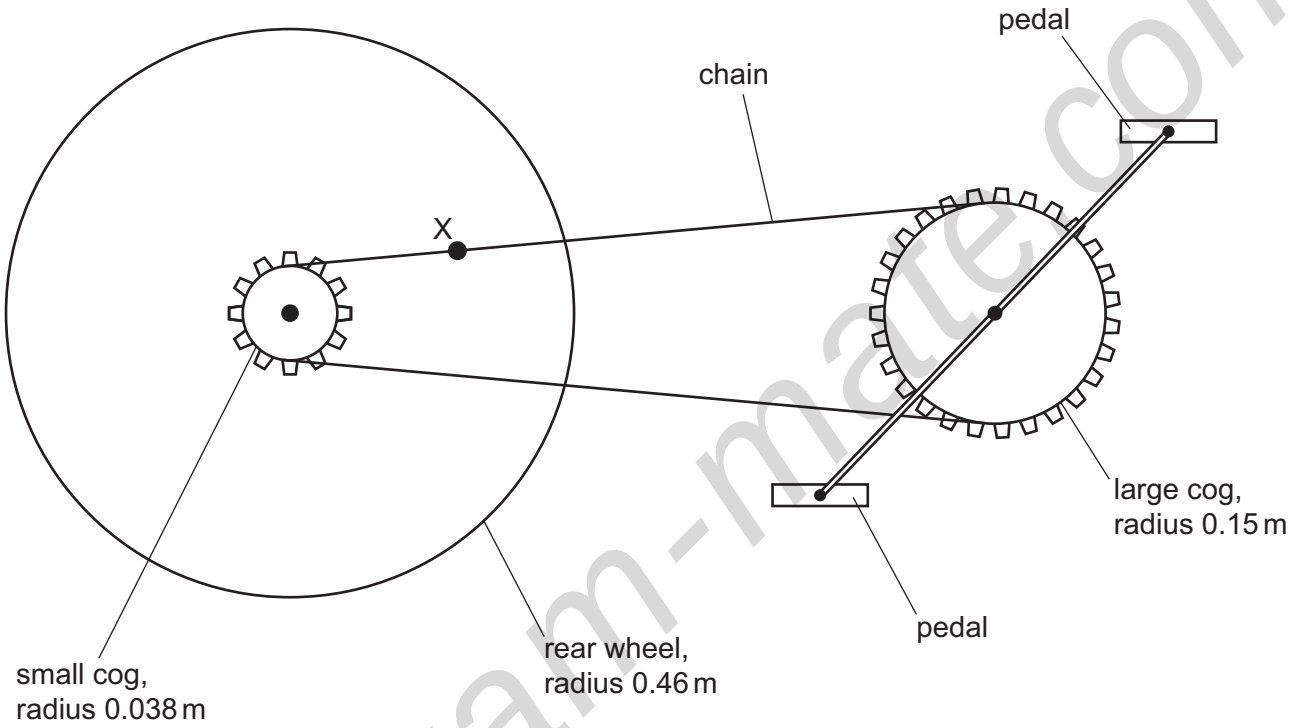


**Fig. 1.1** (not to scale)

The small cog has a radius of 0.038 m and is fixed to the rear wheel so that it rotates with it.
The large cog has a radius of 0.15 m and is fixed to the pedals so that it rotates with them.
The rear wheel has a radius of 0.46 m.

The bicycle is being pedalled so that it moves in a straight line at a constant speed of 17 m $s^{-1}$.

**(i)** Calculate the angular speed of the rear wheel.

angular speed = ..... rad $s^{-1}$ [2]

**(ii)** Calculate the period of rotation of the small cog.

period = ..... s [2]

**(iii)** Show that the distance moved by point X on the chain during one full rotation of the small cog is 0.24 m.

[1]

**(iv)** Use the information in **(b)(iii)** to determine the angle through which the large cog rotates during one full rotation of the small cog.

angle = ..... rad [2]

**(c)** The chain of the bicycle in **(b)** is moved onto a smaller cog fixed to the rear wheel. The speed of the bicycle does not change.

Explain, without calculation, the effect of this change on the angular speed of the pedals.

.....

.....

..... [2]

[Total: 10]

1 - (9702/43_Summer_2023_Q1 ) QUESTION

| | | |
|---|---|---|
| (a)(i) | force per unit mass | **B1** |
| (a)(ii) | force per unit positive charge | **B1** |
| (a)(iii) | similarity:<br>• inversely proportional to distance (from point)<br>• points of equal potential lie on concentric spheres<br>• zero at infinite distance<br>*Any point, 1 mark* | **B1** |
| | difference:<br>• gravitational potential is (always) negative<br>• electric potential can be positive or negative<br>*Any point, 1 mark* | **B1** |
| (b)(i) | $g = GM / r^2$ | **M1** |
| | $E = Q / 4\pi\varepsilon_0 r^2$ | **M1** |
| | algebra showing the elimination of $r$ leading to $M / Q = (1 / 4\pi G\varepsilon_0)\ (g / E)$ | **A1** |
| (b)(ii) | $\alpha = 1 / (4\pi \times 6.67 \times 10^{-11} \times 8.85 \times 10^{-12}) = 1.35 \times 10^{20}$ (kg$^2$ C$^{-2}$)<br>**or**<br>$\alpha = (8.99 \times 10^9) / (6.67 \times 10^{-11}) = 1.35 \times 10^{20}$ (kg$^2$ C$^{-2}$) | **A1** |
| (c)(i) | $E = \alpha g Q / M$<br>$= (1.35 \times 10^{20} \times 9.81 \times 4.80 \times 10^5) / (5.98 \times 10^{24})$ | **C1** |
| | $= 106$ N C$^{-1}$ **or** 106 V m$^{-1}$ | **A1** |
| (c)(ii) | same (direction) | **B1** |

2 - (9702/42_Summer_2025_Q1) QUESTION

| | | |
|---|---|---|
| (a) | angle (subtended at centre of a circle) when arc (length) = radius | **B1** |
| (b)(i) | $v = r\omega$ | **C1** |
| | $\omega$ = 17 / 0.46<br>= 37 rad $s^{-1}$ | **A1** |
| (b)(ii) | $T = 2\pi r / v$ **or** $T = 2\pi / \omega$ | **C1** |
| | = $2\pi \times 0.46 / 17$ **or** $2\pi / 37$<br>= 0.17 s | **A1** |
| (b)(iii) | distance = $2\pi \times 0.038$ = 0.24 m | **A1** |
| (b)(iv) | angle = arc length / radius | **C1** |
| | = 0.24 / 0.15<br>= 1.6 rad | **A1** |
| (c) | point X moves through a smaller distance in the same time<br>**or**<br>(linear) speed of movement of point X / chain decreases<br>**or**<br>(linear) speed of (circumference of) both cogs decreases | **B1** |
| | angular speed (of pedals) decreases | **B1** |