A LEVEL Cambridge Topical Past Papers

PHYSICS

PAPER 4 2017 — 2023

Physics 9702

TOPICAL PAST PAPER WORKSHEETS

2017 - 2023 | Questions + Mark scheme

AVAILABLE PAPERS

P1
1734 Questions

P2
431 Questions

P4
376 Questions

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TOPICS	P1	P2	P4
PHYSICAL QUANTITIES & UNITS	86	29	2
MEASUREMENT TECHNIQUES	81	18	0
KINEMATICS	132	43	0
DYNAMICS	170	46	2
FORCES, DENSITY & PRESSURE	153	32	1
WORK, ENERGY & POWER	163	38	0
MOTION IN CIRCLE	1	1	11
GRAVITATIONAL FIELDS	0	0	26
DEFORMATION OF SOLIDS	73	16	0
IDEAL GASES	5	1	25
TEMPERATURE	0	0	14
THERMAL PROPERTIES OF MATERIALS	1	0	19
OSCILLATIONS	3	0	26
WAVES	228	38	6
SUPERPOSITION	164	36	0
COMMUNICATION	1	0	25
ELECTRIC FIELDS	68	19	24
CAPACITANCE	0	0	16
CURRENT OF ELECTRICITY	179	44	3
D.C. CIRCUITS	115	29	2
ELECTRONICS	4	0	21
MAGNETIC FIELDS	0	0	34
ELECTROMAGNETIC INDUCTION	0	0	28
ALTERNATING CURRENTS	2	0	14
QUANTOM PHYSICS	2	0	34
PARTICLE & NUCLEAR PHYSICS	103	41	27
MEDICAL IMAGING	0	0	10
ASTRONOMY & COSMOLOGY	0	0	6

1 - (9702/41_Summer_2023_Q1) - *Physical Quantities & Units*

(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 α is a constant.

[3]

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

[1]

(c) Assume that the Earth is a uniform conducting sphere of mass 5.98×10^{24} kg.
The surface of the Earth carries a charge of -4.80×10^{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]

2 - (9702/42_Summer_2023_Q1) - *Physical Quantities & Units, Dynamics*

(a) State Newton's law of gravitation.

....

....

.... [2]

(b) A satellite is in a circular orbit around a planet. The radius of the orbit is *R* and the period of the orbit is *T*. The planet is a uniform sphere.

Use Newton's law of gravitation to show that *R* and *T* are related by

$$4\pi^2 R^3 = GMT^2$$

where *M* is the mass of the planet and *G* is the gravitational constant.

[2]

(c) The Earth may be considered to be a uniform sphere of mass 5.98×10^{24} kg and radius 6.37×10^{6} m.

A geostationary satellite is in orbit around the Earth.

Use the expression in **(b)** to determine the height of the satellite above the Earth's surface.

height = ... m [3]

(d) Another satellite is in a circular orbit around the Earth with the same orbital radius and period as the satellite in **(c)**.

(i) Calculate the angular speed of the satellite in this orbit. Give a unit with your answer.

angular speed = ... unit .... [2]

(ii) Despite having the same orbital period, the orbit of this satellite is not geostationary.

Suggest **two** ways in which the orbit of this satellite could be different from the orbit of the satellite in **(c)**.

1 ....

....

2 ....

....
[2]

1 - (9702/41_Summer_2023_Q2) - *Dynamics*

A steel sphere of mass 0.29 kg is suspended in equilibrium from a vertical spring. The centre of the sphere is 8.5 cm from the top of the spring, as shown in Fig. 2.1.

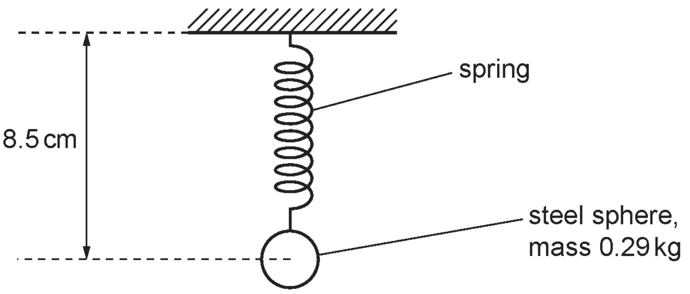

Fig. 2.1

The sphere is now set in motion so that it is moving in a horizontal circle at constant speed, as shown in Fig. 2.2.

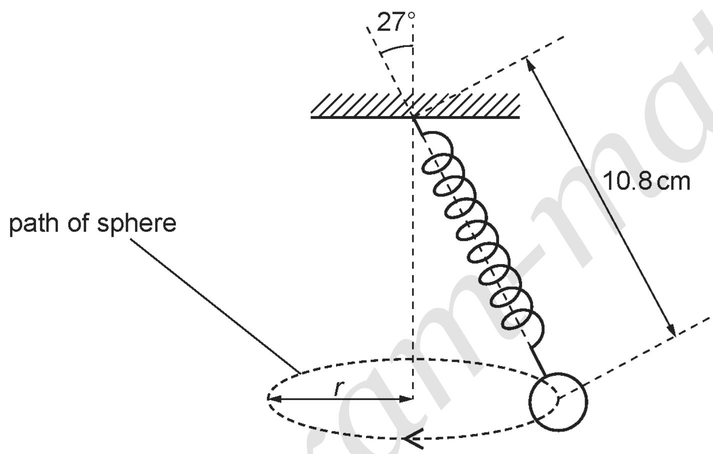

Fig. 2.2

The distance from the centre of the sphere to the top of the spring is now 10.8 cm.

(a) Explain, with reference to the forces acting on the sphere, why the length of the spring in Fig. 2.2 is greater than in Fig. 2.1.

....

....

....

....

.... [3]

(b) The angle between the linear axis of the spring and the vertical is 27°.

(i) Show that the radius r of the circle is 4.9 cm.

[1]

(ii) Show that the tension in the spring is 3.2 N.

[2]

(iii) The spring obeys Hooke's law.

Calculate the spring constant, in $N\,cm^{-1}$, of the spring.

spring constant = ... $N\,cm^{-1}$ [2]

(c) **(i)** Use the information in **(b)** to determine the centripetal acceleration of the sphere.

centripetal acceleration = ... $m\,s^{-2}$ [2]

(ii) Calculate the period of the circular motion of the sphere.

period = ... s [2]

2 - (9702/42_Summer_2023_Q1) - *Physical Quantities & Units, Dynamics*

(a) State Newton's law of gravitation.

....

....

.... [2]

(b) A satellite is in a circular orbit around a planet. The radius of the orbit is R and the period of the orbit is T. The planet is a uniform sphere.

Use Newton's law of gravitation to show that R and T are related by

$$4\pi^2 R^3 = GMT^2$$

where M is the mass of the planet and G is the gravitational constant.

[2]

(c) The Earth may be considered to be a uniform sphere of mass 5.98×10^{24} kg and radius 6.37×10^6 m.

A geostationary satellite is in orbit around the Earth.

Use the expression in **(b)** to determine the height of the satellite above the Earth's surface.

height = ... m [3]

(d) Another satellite is in a circular orbit around the Earth with the same orbital radius and period as the satellite in **(c)**.

(i) Calculate the angular speed of the satellite in this orbit. Give a unit with your answer.

angular speed = ... unit .... [2]

(ii) Despite having the same orbital period, the orbit of this satellite is not geostationary.

Suggest **two** ways in which the orbit of this satellite could be different from the orbit of the satellite in **(c)**.

1 ....

....

2 ....

....
[2]

ANSWERS

1 – (9702/41_Summer_2023_Q1) – *Physical Quantities & Units*

(a)(i)	force per unit mass	B1
(a)(ii)	force per unit positive charge	B1
(a)(iii)	similarity: • inversely proportional to distance (from point) • points of equal potential lie on concentric spheres • zero at infinite distance *Any point, 1 mark*	B1
	difference: • gravitational potential is (always) negative • electric potential can be positive or negative *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}) **or** $\alpha = (8.99 \times 10^9) / (6.67 \times 10^{-11}) = 1.35 \times 10^{20}$ (kg^2 C^{-2})	A1
(c)(i)	$E = \alpha gQ / M$ $= (1.35 \times 10^{20} \times 9.81 \times 4.80 \times 10^5) / (5.98 \times 10^{24})$	C1
	$= 106$ N C^{-1} **or** 106 V m^{-1}	A1
(c)(ii)	same (direction)	B1

2 – (9702/42_Summer_2023_Q1) – *Physical Quantities & Units, Dynamics*

(a)	(gravitational) force is (directly) proportional to product of masses	B1
	force (between point masses) is inversely proportional to the square of their separation	B1
(b)	$GMm / R^2 = mR\omega^2$	M1
	$\omega = 2\pi / T$ <u>and</u> algebra leading to $4\pi^2R^3 = GMT^2$	A1
	or	
	$GMm / R^2 = mv^2 / R$	(M1)
	$v = 2\pi R / T$ <u>and</u> algebra leading to $4\pi^2R^3 = GMT^2$	(A1)
(c)	$4\pi^2 \times R^3 = 6.67 \times 10^{-11} \times 5.98 \times 10^{24} \times (24 \times 60 \times 60)^2$ ($R = 4.22 \times 10^7$ m)	C1
	$h = R - (6.37 \times 10^6)$	C1
	$h = (4.22 \times 10^7) - (6.37 \times 10^6)$ $= 3.6 \times 10^7$ m	A1
(d)(i)	$\omega = 2\pi / T$	C1
	$= 2\pi / (24 \times 60 \times 60)$ $= 7.3 \times 10^{-5}$ rad s^{-1}	A1
(d)(ii)	orbit is from east to west	B1
	orbit is not equatorial / orbit is polar	B1

1 – (9702/41_Summer_2023_Q2) – *Dynamics*

(a)	horizontal force on sphere causes centripetal acceleration	B1
	weight of sphere is (now) equal to vertical component of tension **or** horizontal and vertical components (of force) (now) combine to give greater tension (in spring)	B1
	greater tension in spring so greater extension of spring	B1
(b)(i)	$r = 10.8 \times \sin 27° = 4.9$ cm	A1
(b)(ii)	$T \cos \theta = mg$ **or** $T \cos \theta = W$ **and** $W = mg$	C1
	$T \cos 27° = 0.29 \times 9.81$ leading to $T = 3.2$ N	A1
(b)(iii)	$\Delta T = 3.2 - (0.29 \times 9.81)$	C1
	$k = \Delta T / \Delta x$ $= [3.2 - (0.29 \times 9.81)] / [10.8 - 8.5]$ $= 0.15$ N cm^{-1}	A1
(c)(i)	centripetal acceleration $= (T \sin \theta) / m$ $= (3.2 \times \sin 27°) / 0.29$	C1
	$= 5.0$ m s^{-2}	A1
(c)(ii)	$a = r\omega^2$ **and** $\omega = 2\pi / T$ **or** $a = v^2 / r$ **and** $v = 2\pi r / T$	C1
	$T = 2\pi \times \sqrt{(0.049 / 5.0)}$ $= 0.62$ s	A1

2 – (9702/42_Summer_2023_Q1) – *Physical Quantities & Units, Dynamics*

(a)	(gravitational) force is (directly) proportional to product of masses	B1
	force (between point masses) is inversely proportional to the square of their separation	B1
(b)	$GMm / R^2 = mR\omega^2$	M1
	$\omega = 2\pi / T$ <u>and</u> algebra leading to $4\pi^2R^3 = GMT^2$	A1
	or	
	$GMm / R^2 = mv^2 / R$	(M1)
	$v = 2\pi R / T$ <u>and</u> algebra leading to $4\pi^2R^3 = GMT^2$	(A1)
(c)	$4\pi^2 \times R^3 = 6.67 \times 10^{-11} \times 5.98 \times 10^{24} \times (24 \times 60 \times 60)^2$ ($R = 4.22 \times 10^7$ m)	C1
	$h = R - (6.37 \times 10^6)$	C1
	$h = (4.22 \times 10^7) - (6.37 \times 10^6)$ $= 3.6 \times 10^7$ m	A1
(d)(i)	$\omega = 2\pi / T$	C1
	$= 2\pi / (24 \times 60 \times 60)$ $= 7.3 \times 10^{-5}$ rad s^{-1}	A1
(d)(ii)	orbit is from east to west	B1
	orbit is not equatorial / orbit is polar	B1