Past-paper walk-through

Gravitational Force ▪ 2.6

eXercise

Questions in this set

- 2024 Q4
- 2023 Q2
- 2022 Q2
- 2016 Q3

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 4

2024 ▪ Q4

[Figure showing a pendulum: a rigid horizontal support bracket attached to a wall/ceiling structure, from which a string hangs. The string makes angle θ with the vertical dashed line. At the end of the string is a small sphere labeled "Small Sphere", at position A. A dashed circle labeled B marks the lowest point of the swing, directly below the pivot along the vertical dashed line.]

A simple pendulum consists of a small sphere that hangs from a string with negligible mass. The top end of the string is fixed. The sphere is pulled to Point A so that the string makes a small angle θ with the vertical, as shown. The sphere is then released from rest and swings through its lowest point at Point B. The work done on the sphere by Earth between points A and B is W_E.

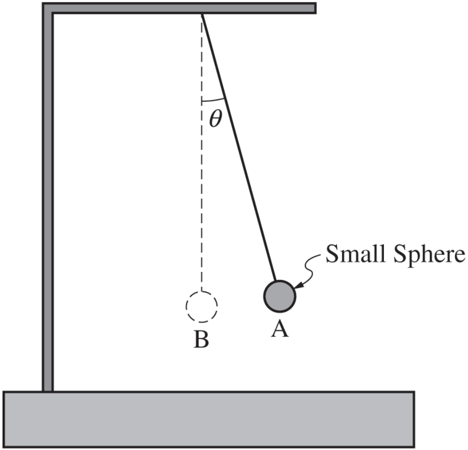
The pendulum is then taken to Planet X. The mass of Planet X is the same as the mass of Earth, but the radius of Planet X is greater than the radius of Earth. The

Question 4

sphere is again brought to Point A (displaced θ from the vertical), released from rest, and swings through its lowest point at Point B. The work done on the sphere by Planet X between points A and B is W_X.

(a) (a) **Justify** why W_X is less than W_E.

Question 4



Question 4

2024 ▪ Q4

[Figure showing a pendulum: a rigid horizontal support bracket attached to a wall/ceiling structure, from which a string hangs. The string makes angle θ with the vertical dashed line. At the end of the string is a small sphere labeled "Small Sphere", at position A. A dashed circle labeled B marks the lowest point of the swing, directly below the pivot along the vertical dashed line.]

A simple pendulum consists of a small sphere that hangs from a string with negligible mass. The top end of the string is fixed. The sphere is pulled to Point A so that the string makes a small angle θ with the vertical, as shown. The sphere is then released from rest and swings through its lowest point at Point B. The work done on the sphere by Earth between points A and B is W_E.

The pendulum is then taken to Planet X. The mass of Planet X is the same as the mass of Earth, but the radius of Planet X is greater than the radius of Earth. The sphere is again brought to Point A (displaced θ from the vertical), released from rest, and swings through its

Question 4

lowest point at Point B. The work done on the sphere by Planet X between points A and B is W_X.

(b) A new pendulum is made by hanging the same small sphere from a different string with negligible mass. The new string is slightly elastic, and the length of the string may increase or decrease depending on the tension applied to the string. On Earth, when the sphere is again displaced θ from the vertical and released from rest, the new pendulum oscillates with period T_E.

The new pendulum is then taken to a different planet, Planet Y. The radius of Planet Y is the same as the radius of Earth, but the mass of Planet Y is larger than the mass of Earth. On Planet Y, when the sphere is again displaced from the vertical and released from rest, the new pendulum oscillates with period T_Y.

(b) In a clear, coherent paragraph-length response that may also contain drawings, **explain** how T_Y <u>could be larger</u> than T_E but also <u>could be smaller</u> than T_E.

Solution 4

(a) Mark scheme

- Because Planet X has a larger radius than Earth (same mass sphere/planet setup), the gravitational force (equivalently the gravitational field strength or acceleration due to gravity) is smaller on Planet X. Since the sphere travels the same vertical distance in both scenarios, and work done equals force times distance, the smaller gravitational force on Planet X means less work is done on the sphere there — so $W_X < W_E$. Points: indicating one of — gravitational force, gravitational field strength, or acceleration due to gravity would be smaller for the greater radius (1 point); indicating one of — the sphere travels the same vertical distance in both scenarios, the work done depends on the magnitude of the gravitational force, or the change in gravitational potential energy is less on Planet X (1 point).

Solution 4

(b) Mark scheme

- Argument: the pendulum period is $T = 2\pi\sqrt{\ell/g}$. On Planet Y, since the planet's mass is larger, the gravitational force on the sphere (and hence its weight, and the gravitational field strength g) is larger than on Earth, so the sphere experiences a larger acceleration due to gravity on Planet Y. Because g is in the denominator of the period equation, a larger g alone would tend toward a smaller period. However, the larger gravitational force on the sphere also means a greater stretching force on the (slightly elastic) string, so the string — and hence the pendulum length ℓ — could increase. Since T increases with ℓ, a longer string could push the period back up. So the net effect on T depends on which change (larger g vs. longer ℓ) dominates. Points (5 total, 1 each): relating a larger

Solution 4

planetary mass to a larger weight of the sphere / larger g / larger gravitational field strength; indicating the period is inversely related to g (or gravitational field strength); indicating the amount of string stretch depends on the weight of the sphere / g / gravitational field strength; relating the length of the string to the period of the pendulum; and an overall logical, relevant, internally consistent argument that addresses the question and follows the paragraph-response format.

Question 2

2023 ▪ Q2

[Figure: A cart on an inclined ramp. The ramp rises from lower right to upper left. At the top of the ramp, the origin $x = 0$ is marked with a small cart icon, and an arrow labeled $+x$ points down the incline (down and to the right) indicating the positive x-direction along the ramp's surface.]

Students conduct an experiment to determine the acceleration a of a cart. The cart is released from rest at time $t = 0$ and moves down the ramp. The x-axis is defined to be parallel to the ramp with its origin at the top, as shown in the figure. The students collect the data shown in the following table.

Position x (m)	**Time t (s)**
0.06	0.39
0.14	0.59
0.24	0.77
0.37	0.96
0.55	1.20

Question 2

(a)(i) Indicate which quantities could be graphed to yield a straight line whose slope could be used to determine the acceleration *a* of the cart. You may use the remaining columns in the table, as needed, to record any quantities (including units) that are not already in the table.

Vertical axis: ____________________ Horizontal axis: ____________________

(a)(ii) [Continuation of Question 2.] On the following grid, plot the appropriate quantities to create a graph that can be used to determine the acceleration *a* of the cart as it rolls down the ramp. Clearly scale and label all axes (including units), as appropriate. Draw a straight line that best represents the data.

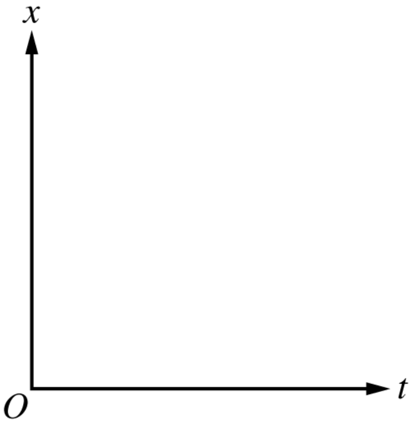
[Blank labeled grid for plotting, approximately 20 columns by 15 rows of light gridlines, no axes pre-drawn or pre-labeled.]

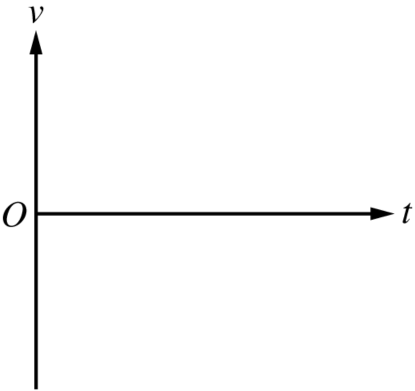
Question 2

(a)(iii) iii. Using the line you drew in part (a)(ii), calculate an experimental value for the acceleration *a* of the cart as it rolls down the ramp.

Question 2

Question 2





Question 2