AP PHYSICS C: MECHANICS • EXERCISE SHEET

7.5 Simple and Physical Pendulums

Name: _____ Class: _____ Date: _____ **Total: 13 marks**

KEY WORDS simple pendulum 单摆 • physical pendulum 物理摆 • period 周期 • amplitude 振幅

Objective

Build the skills to answer exam questions on **simple and physical pendulums**.

You must be able to:

- use the **simple pendulum** 单摆 period: $T = 2\pi\sqrt{L/g}$
- use the **physical pendulum** 物理摆 period: $T = 2\pi\sqrt{I/(mgd)}$
- identify d as the pivot-to-centre-of-mass distance and I as the inertia about the pivot
- recognise the simple pendulum as a special case of the physical one

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ The simple pendulum

A point mass on a light string of length L:

$$T = 2\pi\sqrt{\frac{L}{g}}.$$

■ The physical pendulum

Any rigid body swinging about a pivot:

$$T = 2\pi\sqrt{\frac{I}{mgd}},$$

where I is about the pivot and d reaches the centre of mass.

■ One is a special case of the other

For a point mass at distance L, $I = mL^2$ and $d = L$, so $T = 2\pi\sqrt{mL^2/(mgL)} = 2\pi\sqrt{L/g}$.

2 Practice

Now apply the methods above.

2.1 A simple pendulum has $L = 0.25$ m ($g = 9.8$ m s^{-2}). Find its period. [2]

2.2 In $T = 2\pi\sqrt{I/(mgd)}$, what is d? [1]

2.3 State whether making a pendulum's bob heavier changes its period. [1]

2.4 For a physical pendulum, about which axis must I be measured? [1]

3 Exam-style questions

3.1 The period of a simple pendulum increases if you [1]

- **A** increase the mass
- **B** increase the length
- **C** increase the amplitude
- **D** paint it black

3.2 The simple-pendulum formula is a special case of the [1]

- **A** mass-spring formula
- **B** physical-pendulum formula
- **C** ideal gas law
- **D** work-energy theorem

3.3 A uniform rod of length L is pivoted at one end, with $I = \frac{1}{3}mL^2$ and $d = L/2$.

(a) Write its period in terms of L and g. [2]

(b) State whether it swings faster or slower than a simple pendulum of the same length. [1]

3.4 A pendulum has $L = 1.0$ m ($g = 9.8$ m s^{-2}).

(a) Find its period. [2]

(b) State the effect of moving it to the Moon (smaller g). [1]

Solutions

2.1 $T = 2\pi\sqrt{L/g} = 2\pi\sqrt{0.25/9.8} \approx 1.0$ s.

2.2 The distance from the pivot to the centre of mass.

2.3 No (mass cancels).

2.4 About the pivot.

3.1 **B** — increasing the length increases the period.

3.2 **B** — the physical-pendulum formula.

3.3 (a) $T = 2\pi\sqrt{\dfrac{\frac{1}{3}mL^2}{mg(L/2)}} = 2\pi\sqrt{\dfrac{2L}{3g}}$. (b) Slightly faster (shorter effective period).

3.4 (a) $T = 2\pi\sqrt{1/9.8} \approx 2.0$ s. (b) The period gets longer (smaller g).