Exercise walk-through

Simple and Physical Pendulums ▪ 7.5

eXercise

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

Method — The simple pendulum

A point mass on a light string of length L:

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

Method — 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.

Method — One is a special case of the other

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

Practice 2.1 ▪ 2 marks

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

Solution 2.1

Method: The simple pendulum

Worked steps

$T = 2\pi\sqrt{L/g} = 2\pi\sqrt{0.25/9.8} \approx 1.0$ s **M1** **A1**.

Practice 2.2 ▪ 1 mark

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

Solution 2.2

Worked steps

The distance from the pivot to the centre of mass B1.

Practice 2.3 ▪ 1 mark

State whether making a pendulum's bob heavier changes its period.

Solution 2.3

Worked steps

No (mass cancels) B1.

Practice 2.4 ▪ 1 mark

For a physical pendulum, about which axis must I be measured?

Solution 2.4

Method: The physical pendulum

Worked steps

About the pivot B1.

Exam-style 3.1 ▪ 1 mark

The period of a simple pendulum increases if you

A increase the mass

B increase the length

C increase the amplitude

D paint it black

Solution 3.1

Method: The simple pendulum

A increase the mass

B increase the length ✓

C increase the amplitude

D paint it black

Worked steps

B — increasing the length increases the period.

Exam-style 3.2 ▪ 1 mark

The simple-pendulum formula is a special case of the

A mass-spring formula

B physical-pendulum formula

C ideal gas law

D work-energy theorem

Solution 3.2

A mass-spring formula

B physical-pendulum formula ✓

C ideal gas law

D work-energy theorem

Worked steps

B — the physical-pendulum formula.

Exam-style 3.3 ▪ 2 marks

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

Solution 3.3

Method: The simple pendulum

Worked steps

(a) $T = 2\pi\sqrt{\dfrac{\frac{1}{3}mL^2}{mg(L/2)}} = 2\pi\sqrt{\dfrac{2L}{3g}}$ M1 A1. (b) Slightly faster (shorter effective period) B1.

Exam-style 3.4 ▪ 2 marks

A pendulum has $L = 1.0$ m ($g = 9.8$ m s^{-2}).
(a) Find its period.
(b) State the effect of moving it to the Moon (smaller g).

Solution 3.4

Worked steps

(a) $T = 2\pi\sqrt{1/9.8} \approx 2.0$ s M1 A1. (b) The period gets longer (smaller g) B1.