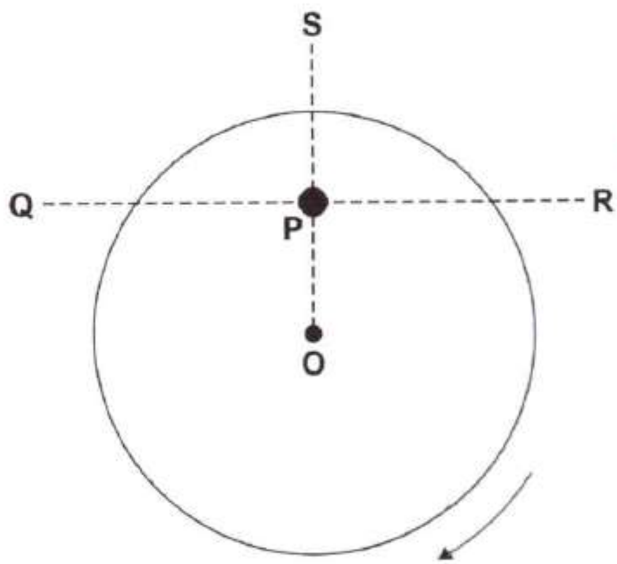
Periodic motion – A2 Physics P1

1. June/2024/Paper_7408/1/No.28

A small mass is placed at **P** on a horizontal turntable. The turntable rotates clockwise with a constant angular speed about a vertical axis through its centre **O**.

view of turntable from above



The mass, while stationary, undergoes circular motion, and centripetal force acts on it, towards the center O, which is provided by the static

The mass remains at rest relative to the turntable.

What is the direction of the frictional force on the mass at the instant shown?

[1 mark]

frictional force between mass and the rotating turntable. Since static force supplies the centripetal force, then it must also be in the same direction P to O.

A from **P** to **O** ☒

B from **P** to **Q** ☐

C from **P** to **R** ☐

D from **P** to **S** ☐

2. June/2024/Paper_7408/1/No.29

A particle of mass m moves in a circle of radius r. The number of revolutions completed per second is f.

What is the kinetic energy of the particle?

[1 mark]

A $4\pi^2 m f^2 r^2$

B $2\pi^2 m f^2 r^2$

C $\dfrac{m f^2 r^2}{4\pi^2}$

D $\dfrac{m f^2 r^2}{2}$

$\omega = 2\pi f$

and

$v = r\omega$

$= r(2\pi f)$

$= 2\pi f r$

$KE = \frac{1}{2} m v^2$

$= \frac{1}{2} \times m \times (2\pi f r)^2$

$= \frac{1}{2} m \cdot 4\pi^2 f^2 r^2$

$= 2\pi^2 m f^2 r^2$

3. June/2024/Paper_7408/1/No.30

A body is in simple harmonic motion of amplitude $0.60\ \text{m}$ and period 2π seconds.

What is its speed when its displacement is $0.20\ \text{m}$?

[1 mark]

A $0.32\ \text{m s}^{-1}$

B $0.57\ \text{m s}^{-1}$

C $0.63\ \text{m s}^{-1}$

D $22\ \text{m s}^{-1}$

$\omega = \frac{2\pi}{T}$ with $T = 2\pi$

So

$\omega = \frac{2\pi}{2\pi} = 1\ \text{rad/s}$

Since

$v = \pm\omega\sqrt{A^2 - x^2}$, then

$v = \pm 1\sqrt{0.6^2 - 0.2^2}$

$v = \pm\sqrt{0.32}$

$v = \pm 0.566\ \text{m/s}$

4. June/2024/Paper_7408/1/No.31

When a mass **M** is suspended from a spring, the spring extends by a distance x.
M is displaced vertically and, when released, it oscillates with a period T.

M is removed and suspended from a different spring. The spring extends by a distance $\frac{x}{2}$.

M is again displaced vertically and released.

What is the new period of oscillations of **M**?

[1 mark]

Given

$T = 2\pi\sqrt{\frac{M}{k}}$

from Hookes Law

A $\frac{T}{2}$ ☐

$Mg = kx \Rightarrow k = \frac{Mg}{x}$

so

B $\frac{T}{\sqrt{2}}$ ☒

$T = 2\pi\sqrt{\frac{M}{\frac{Mg}{x}}} = 2\pi\sqrt{\frac{x}{g}}$

C $T\sqrt{2}$ ☐

for Spring 2

$Mg = k'\left(\frac{x}{2}\right) \Rightarrow k' = \frac{2Mg}{x}$

D $2T$ ☐

So: $T' = 2\pi\sqrt{\frac{M}{k'}} = 2\pi\sqrt{\frac{M}{\frac{2Mg}{x}}} = 2\pi\sqrt{\frac{x}{2g}} = \frac{2\pi}{\sqrt{2}}\sqrt{\frac{x}{g}} = \frac{T}{\sqrt{2}}$

5. June/2024/Paper_7408/1/No.32

A mass–spring system and a simple pendulum have identical periods of oscillation T when at the surface of the Earth.

Both are taken to planet **X** where the acceleration due to gravity is $\frac{g}{2}$.

What are the periods of the mass–spring system and the simple pendulum on **X**?

[1 mark]

$T = 2\pi\sqrt{\frac{m}{k}}$, so T is independent of g, so period remains the same.

	Period of mass–spring system	Period of simple pendulum	
A	$\frac{T}{2}$	$T\sqrt{2}$	☐
B	T	$2T$	☐
C	T	$T\sqrt{2}$	☒
D	$T\sqrt{2}$	T	☐

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

So;

And $T' = 2\pi\sqrt{\frac{L}{g/2}} = 2\pi\sqrt{\frac{2L}{g}} = \sqrt{2} \times 2\pi\sqrt{\frac{L}{g}} = T\sqrt{2}$