SHM – Questions 3

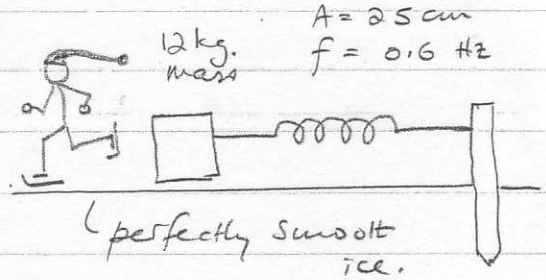
A2 Physics

Earth $g = 10$ N/kg

Moon $g = 1.6$ N/kg

1. What is the ....

$A = 25$ cm
$f = 0.6$ Hz



(a) Time period? (2)

(b) Max velocity, and where? (3)

(c) max acceleration, and where? (3)

(d) spring stiffness? (2)

(e) Sketch graphs of displacement and velocity and acceleration against time (4 + 2 + 2).

(f) What is the max k.e. of the mass? (2)

(g) What is the max P.E. stored in the spring? (3)

(h) Any comment on answers to (f) and (g)? (2)

(i) What is the displacement of the mass from the centre of oscillation 1.0 sec after the time of maximum compression of the spring.
Sketch a diagram to show where the mass is, and which way it is moving. (4)

(j) What must the amplitude be for the mass to have a maximum acceleration of 6 m/s^2? (2)

2. A spring of unstretched length 5 cm has a 250 g mass hung from it, and the new length is 9.5 cm

(a) Spring constant (2)

(b) What would be the frequency of oscillation of a 400 g mass hung on the spring on the Moon? (3)

(c) 2 springs are joined end to end and a 500 g mass hung from the lower spring.
Sketch the arrangement ... calculate k for the 2 springs, ... and T. (3)

(d) The 2 springs are joined in parallel at the ends.
Sketch ... calculate k for this arrangement and T for a 500 g mass (3)

(e) The Time period for n springs connected in parallel is T_n sec.
Can you show that $T_n = \frac{T_1}{\sqrt{n}}$, where T_1 is time period for 1 spring? (2)

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$\boxed{1}/31$ $\boxed{2}/13$.

SHM — 3 Answers

A2 Physics

1. a) $T = 1/f = 1.67$ Hz (2 s.f.) ②

(b) $v_{max} = \omega A = 2\pi f A = \underline{0.94}$ m/s at the centre, $x = 0$ ③

(c) $a_{max} = -\omega^2 A = (2\pi f)^2 A = \underline{3.55}$ m/s² at max displacement ③

(d) Use $T = \frac{1}{f} = 2\pi\sqrt{\frac{m}{k}} \Rightarrow \frac{1}{f \times 2\pi} = 0.265 = \sqrt{\frac{m}{k}} \Rightarrow \frac{m}{k} = 0.070 \Rightarrow k = \underline{170}$ N/m (2)

(e) ⇨ ⑧

(f) $KE_{max} = \frac{1}{2} m v_{max}^2 = \underline{5.3\ J}$ ②

(g) PE_{max} in spring $= \frac{1}{2} F_{max} \times A = \frac{1}{2} k A^2$

$= 5.3$ J ③

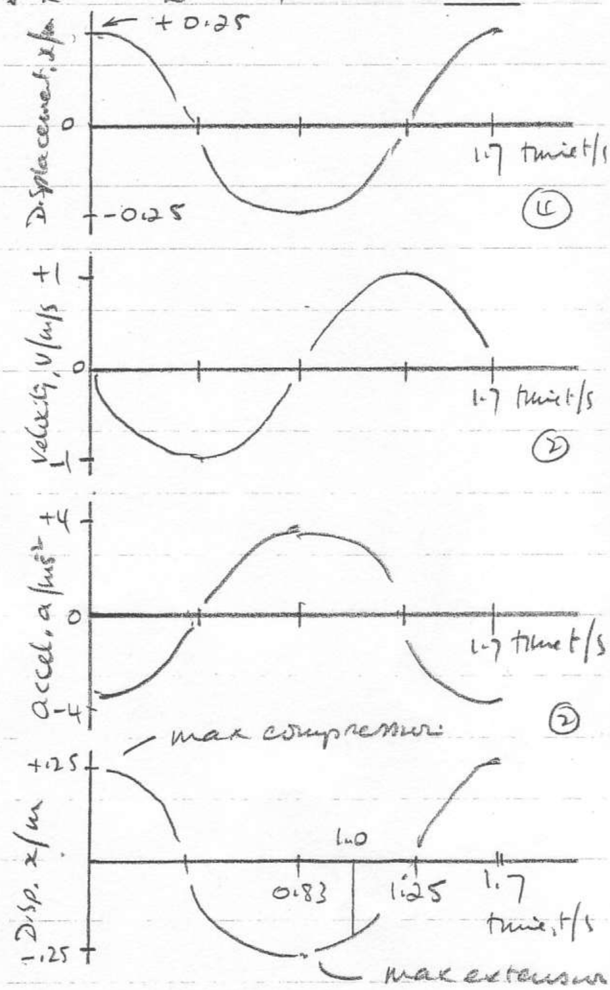
(h) no energy loss ... it just transfers between KE of mass + PE of spring.

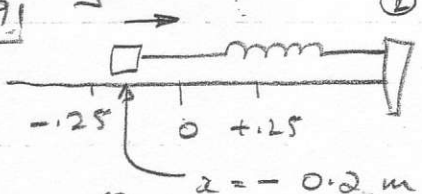
(i) use $x = A \cos \omega t = A \cos 2\pi f t$

$= 0.25 \cos(2\pi \times 0.6 \times 1.0)$

$= -0.202$ m

helpful graphs



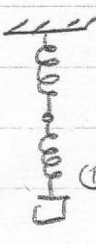


(j) for $a_{max} = 6 = \omega^2 A \Rightarrow A = \underline{0.42}$ m ②

2(a) $k = F/x = \frac{2.5\ (N)}{4.5 \times 10^{-2}} = \underline{56}$ N/m (2)

(b) $T = 2\pi\sqrt{m/k} = 2\pi\sqrt{0.4/56} = 0.53 \Rightarrow f = \underline{\underline{1.88\ Hz}}$

(c)

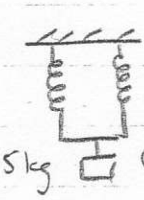


$k = \frac{1}{2} \times k$ (1 spring)

$= 28$ N/m

① $T = 2\pi\sqrt{\frac{0.5}{28}} = \underline{0.84\ s}$ ③

(d)



$T = 2 \times k$ (1 spring) $= 112$ N/m

$T = 2\pi\sqrt{0.5/112}$

① $= \underline{0.42}$ s ③

(e)

n springs... k (n springs) $= n \times k$ (1 spring) or... $k_n = n \times k_1$

so if $T_{1\,spring} = 2\pi\sqrt{m/k_1}$

then $T_n = 2\pi\sqrt{m/k_n} = 2\pi\sqrt{\frac{m}{n k_1}} = 2\pi\sqrt{\frac{m}{k_1}} \times \frac{1}{\sqrt{n}} = T_1 \times \frac{1}{\sqrt{n}} = \frac{T_1}{\sqrt{n}}$ ②

TJN

Dec '02