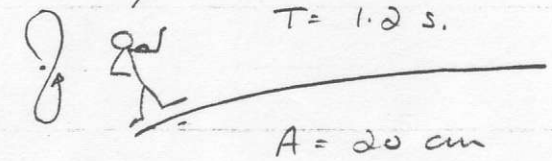
S. H. M. – {Questions} 1

A Physics
$g_{Earth} = 10\ N/kg$
$g_{moon} = 1.6\ N/kg$

A. **Basic S.H.M.** * mass 50g.

1. An object* performs S.H.M. with an amplitude of 5 cm and time period of 4 seconds.
   (a) Sketch a displacement/time graph, showing 2 cycles (5)
   What is ... (b) frequency (2) (c) displacement at 0.5 s? (2)
   (d) acceleration at x = 2 cm? (2) (e) max. acceleration? (2)
   (f) maximum force on object and where in the cycle? (3)
   (g) max. K.E. of object and where in the cycle? (3) [19]

2. A high diver bounces on a springboard, as shown → What is ... (a) frequency? (2)



   (b) Displacement at 0.5 s.? (2)
   (c) maximum acceleration? (2)
   (d) maximum force the board exerts on the diver, and when? (3)
   (e) What is the maximum amplitude the board can have for the diver always to remain in contact? (3) [12]

3. A car engine piston has a mass of 400 g, and moves with an amplitude of 40 mm, with an engine speed of 5000 rpm.
   Calculate (a) the frequency of S.H.M. (2)
   (b) the maximum force on the piston (3)
   (c) the piston's max. K.E. (2)
   (d) Is there any significant difference between the forces on the piston at the top and bottom of its movement? (2) [9]

4. What is the ratio of lengths of "1.0 Seconds" pendulums on Earth and on the moon? (3)
   (Can you do this without working out the actual lengths of each?)

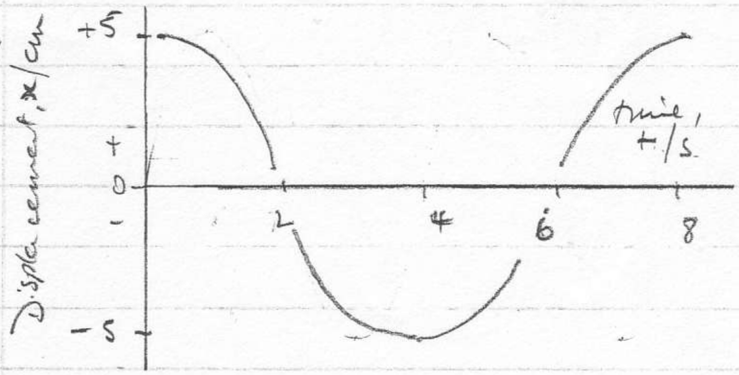
TN
3.98

SHM – ① – Answers

think about calculating ω from $\omega = 2\pi f = \frac{2\pi}{T}$ so you don't need to handle $(2\pi ft)$

A Physics

Ⓐ Basic SHM



1. axes – 2 each; 2 cycles 1 } 5 total

(b) $f = 1/T = 0.25$ Hz (2)

(c) $x = A\cos\omega t = A\cos 2\pi f t$
$= 3.51$ cm (2)

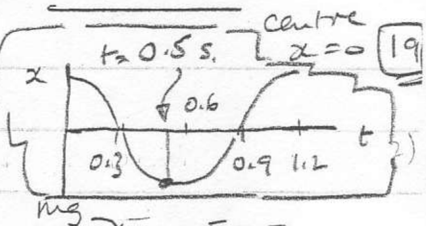
(d) $a = -\omega^2 x$ [$\omega = 2\pi f = 1.57$ rad/s]
$= 4.9$ cm/s² $= 0.049$ m/s² — towards centre

(e) $a_{max} = -\omega^2 A = 12.3$ cm/s² $= 0.123$ m/s² (2)

(f) $F_{max} = m a_{max} = 50\times10^{-3} \times 0.123 = 6.2\times10^{-3}$ N (2) ; at ends of cycle (1)

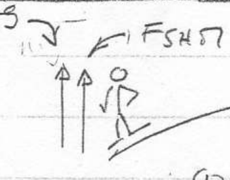
(g) $v_{max} = \omega A = 0.079$ m/s $KE_{max} = \frac{1}{2}mv_{max}^2 = 1.54\times10^{-4}$ J at centre $x = 0$ [19]

2. DIVER (a) $f = 1/T = 0.833$ Hz (2)



(b) $\omega = 2\pi f = 5.23$ rad/s $x = A\cos(\omega t) = -0.17$ m

(c) $a_{max} = -\omega^2 A = 5.48$ m/s² (2)



(d) F_{max} for SHM $= m a_{max} = 439$ N ②
F_{max} occurs at bottom of SHM and $= mg + m a_{max}$
$= 800 + 439 = 1239$ N ① (3)

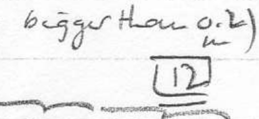
(e) for max amplitude, A_{max} $a_{max} = \omega^2 A_{max}$ ① $= 10$ ① m/s²
So max amplitude $= 10/\omega^2 = 0.36$ ① m (bit bigger than 0.2 m) [12]

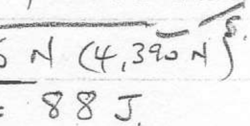
3. (a) 5000 rpm $= 5000/60 = 83.3$ revs/sec (Hz) (2) { $\omega = 2\pi f = 523.6$ rad/s }

(b) $a_{max} = \omega^2 A = 10{,}966$ m/s² → $F_{max} = m a_{max} = 4386$ N (4,390 N)

(c) KE_{max}: $v_{max} = \omega A = 20.9$ m/s → $KE_{max} = \frac{1}{2}mv_{max}^2 = 88$ J.

(d) $F_{resultant}$ top $= F_{SHM} - mg = 4386 - 4 = 4382$ N
$F_{resultant}$ bottom $= F_{SHM} + mg = 4386 + 4 = 4390$
Difference $= 8/4390 \times 100 = 0.18\%$ not significant





[9]

4 Use $T = 2\pi\sqrt{l/g}$ so length $l = T^2 g / 4\pi^2$ ①
$l_{Earth} = 0.253$ ① m $l_{moon} = 0.0405$ m $\frac{l_{Earth}}{l_{moon}} = 6.2$ ① (3)

or… $\frac{l_{Earth}}{l_{moon}} = \frac{T^2 g_{Earth}}{4\pi^2} \times \frac{4\pi^2}{T^2 g_{moon}} = \frac{g_E}{g_m} = \frac{10}{1.6} = 6.25$

TLH
3.98
+ 11.02

Q… ① /19 ② /12 ③ /9 ④ /3