**KNOW THE EQUATIONS:**

**Simple Harmonic Motion Review**

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| Equation |  | Symbol’s **complete** name And SI unit | Situation where equation is most commonly used (or notes about this equation). |
|  | ω | Angular freq (or velocity) (rad s-1) | 1. Conversion equation since EVERY CIRCLE = 2π RADIANS  In SHM, ω = angular frequency = rate of change of angle in reference circle. |
| f | Frequency (Hz) |
|  | T | Period (s) | 2. Can be seen as . f also known as “number of cycles per second” |
|  | a | Acceleration (linear)  (ms-2) | 3. SHM Equation. Both rules must be stated if asked “what is SHM?”:  1st rule of SHM:  negative because acceleration ALWAYS back towards equilibrium (opposite direction to y)  Also fulfils 2nd rule: acc directly proportional to y |
| ω | Angular frequency (or velocity) (rad s-1) |
| y | Displacement from Equilibrium (m) |
|  | F | Restorative Force (N) | 4. Force could be paired with F=mg for springs to find k.  NEGATIVE to show F opposes extension (y) and is in same direction as acceleration (#25) |
| k | Spring Constant (Nm-1) |
|  | T | Period (of pendulum) (s) | 5. For simple 2D pendulums only.  Can be paired with  or  for SHM situations |
| l | Length (of pendulum) (m) |
| g | Gravity (acceleration) (ms-2) |
|  | m | Mass on spring (kg) | 6. Period of mass on spring. For simple 1D mass motion (vertically usually). Can be paired with  or  for SHM situations |
|  | E | Elastic Potential Energy  (in spring) (J) | 7. Can be paired with or  for energy conservation.  At maximum amplitude y can be replaced with A to find “total energy”. |
|  | A | Amplitude of SHM (m) | Calculator MUST be in “radian” mode to do sin properly.  SHM equation set for object starting at equilibrium moving UPWARDS.  Can be expressed as PHASORS with y horizontal to right, v vertical and acc horizontal to left – all spinning anticlockwise at ω. |
| ω | Angular Frequency  (rad s-1) |
| t | Time since sine wave started (s) |
|  | v | Linear velocity (ms-1) |
|  | a | Linear acceleration (ms-2) |
|  |  |  | Calculator MUST be in “radian” mode to do sin properly.  SHM equation set for object starting at top of motion (momentarily motionless).  Can be expressed as PHASORS with y vertically upwards, v horizontal to left and acc vertically downwards – all spinning anticlockwise at ω. |
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**Know the MEANINGS of the key-words or common terms**

1. simple harmonic motion rule #1
2. simple harmonic motion rule #2
3. equilibrium
4. amplitude
5. period
6. frequency
7. angular frequency
8. linear displacement
9. linear velocity
10. linear acceleration
11. locations of vmax and amax.
12. angular displacement
13. angular velocity
14. principle of conservation of energy
15. elastic potential energy
16. gravitational potential energy
17. kinetic energy
18. force constant (spring constant)
19. restorative force
20. free body force diagram
21. friction
22. weight
23. tension
24. phasor
25. reference circle
26. forced SHM
27. resonance
28. resonant frequency
29. damping or damped SHM
30. radian

**Be familiar with the COMMON DIAGRAMS and GRAPHS in this unit:**

(and know the details, labels, possible equations and *explanations* that accompany them)

2

?1

?2

?3

?4

?5

?6

1

?4

?1

?2

?3

?5

?6

?7

?2

?1

Time (s)

?3

?4

?5

4

12cm

Displacement Phasor:

Radius = A = 14cm

Period = T = 2.5s

14cm

θ

3

Explain shaded section and find time for shaded section.

Simple Harmonic Motion Revision Question Set

**QUESTION ONE:** Bouncin’ Baby



Bouncinette

Oscillation direction

|  |  |
| --- | --- |
| Julia has a baby brother whom she looks after for her mother. She put him in his bouncinette, (a bouncy lie-in seat) as shown in the photo. Julia notices that the high end of the bouncer deflects downwards by 0.15 m when the baby is placed in it. The bouncinette can be thought of as a spring, so it will have a spring constant which can be calculated. Her Baby brother has a mass of 6.5 kg.  (a) Show that the bouncinette’s spring constant is 420Nm-1. (2 significant figures)  As the baby moves he causes the bouncinette to oscillate up and down. Over small angles the end of the bouncer appears to move in simple harmonic motion. | 0.15m  Side view |

(b) Show that the period of the baby’s oscillatory motion is 0.78s.

(c) What is the angular frequency (ϖ) of the baby’s motion?

Julia pushes the bouncinette down with the baby in it.

(d) Calculate the maximum acceleration the baby experiences if Julia pushes the bouncinette down 7.5 cm.

(e) Where in the motion does this maximum acceleration occur?

(f) Explain, in terms of accelerations, what could happen to the baby if the bouncinette was pushed down further 17 cm and released.

(g) Using the reference circle below or otherwise, show that the time it takes for the bouncinette to go from position A in its motion (3.75 cm below the resting point) to position B in its motion (3.75 cm above the resting point) is 0.13 s. The maximum oscillation amplitude (A) for the motion is 7.5 cm (radius of the reference circle). The period of oscillation is 0.78 s.

7.5cm

**A**

**B**

3.75cm

3.75cm

|  |  |  |  |
| --- | --- | --- | --- |
| **QUESTION TWO:** Rock Climbing  Pascal is lead climbing as shown below. This means he climbs up pulling a safety rope behind him. Someone below holds this rope. He puts safety devices into the rock face as he climbs up to hold the rope.  He falls off but is held by his safety rope. At a length 5.08 m below the highest safety device the rope begins to extend.  The rope has a spring constant of 208 Nm-1. Pascal’s mass is 74.4 kg.  (a) Pascal bounces up and down on the end of the rope until he comes to rest. Calculate the rope’s extension with Pascal hanging on the end.  When Pascal first fell the rope stretched until it was 11.8 m below the safety device. He then oscillated vertically with Simple Harmonic Motion.  Maximum stretched length 11.8m  Unstretched length 5.08m | |  | |
| (b) What is the length from the safety device to the centre of the oscillation?  (c) Show that the period of oscillation of Pascal on the rope is 3.76 s.  (d) At one stage of the oscillations the amplitude was 3.21m.  Calculate the maximum acceleration at this stage. |  | |

(e) Where does this maximum acceleration occur?

(f) By comparing the acceleration in part (e) to the acceleration due to gravity make a judgement on how uncomfortable Pascal would find this.

The rope’s designers have included a damping feature in its structure. It damps off the motion within 5 oscillations.

(g) What does damping mean and what must the rope’s structure do to the simple harmonic system to achieve this?

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| QUESTION THREE: Car Piston  In a car engine the piston moves up and down in the cylinder to power the engine. The diagram below shows the piston-cylinder assembly. The motion of the piston in a car engine is approximately simple harmonic. The amplitude of the piston is 0.055m and its frequency of oscillation is 140Hz. | Cylinder  Piston  t = 0 |

(a) Explain the meaning of the term “simple harmonic motion”.

(b) Show that the value of the angular frequency for the piston is 880.

State the appropriate SI unit with your unrounded answer.

(c) Calculate the total distance travelled by the piston in 1 complete cycle.

(d) Calculate the maximum speed of the piston.

(e) Sketch the velocity-time graph of the piston’s motion for one complete cycle. Assume t=0 when the piston is at the equilibrium position and moving upwards. Label any available values for time and velocity.

(f) Calculate the maximum acceleration of the piston.

(g) Where does the maximum acceleration take place during the motion of the piston? Give a reason for your answer.