Edexcel A2 Physics: Oscillations – Calculation Practice

Praneel Physics

1. A mass-spring system has a spring constant $k = 200\,\text{N/m}$. If the mass attached to the spring is $2\,\text{kg}$, calculate the natural frequency of the system. **(P)**

Working and Answer:

Natural frequency $f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}, f = \frac{1}{2\pi}\sqrt{\frac{200}{2}} = \frac{1}{2\pi}\sqrt{100} = \frac{10}{2\pi} \approx 1.59\,\text{Hz}$. Answer: $1.59\,\text{Hz}$

2. A pendulum has a length of 1.5 m. Calculate the period of the pendulum. **(P)**

Working and Answer:
Period $T = 2\pi\sqrt{\frac{L}{g}}, T = 2\pi\sqrt{\frac{1.5}{9.81}} \approx 2\pi\sqrt{0.153} \approx 2\pi \times 0.39 \approx$ 2.45 s. Answer: 2.45 s

3. A mass on a spring oscillates with an amplitude of 0.1 m and a frequency of 2 Hz. Calculate the maximum speed of the mass. **(P)**

Working and Answer:
Maximum speed $v_{\max} = A \cdot \omega, \omega = 2\pi f = 2\pi \times 2 = 4\pi$ rad/s, $v_{\max} = 0.1 \cdot 4\pi \approx$ 1.26 m/s. Answer: 1.26 m/s

4. A simple harmonic oscillator has a total energy of 50 J and a mass of 2 kg. Calculate the maximum displacement if the spring constant is 200 N/m. **(P)**

Working and Answer:
Total energy $E = \frac{1}{2}kA^2, 50 = \frac{1}{2} \cdot 200 \cdot A^2, A^2 = \frac{50 \cdot 2}{200} = \frac{100}{200} = 0.5, A = \sqrt{0.5} \approx 0.71$ m. Answer: 0.71 m

5. A mass of 0.5 kg is attached to a spring with a spring constant of 100 N/m. Calculate the potential energy stored in the spring when it is compressed by 0.2 m. **(P)**

Working and Answer:
Potential energy $PE = \frac{1}{2}kx^2, PE = \frac{1}{2} \cdot 100 \cdot (0.2)^2 = \frac{1}{2} \cdot 100 \cdot 0.04 =$ 2 J. Answer: 2 J

6. A pendulum swings with a maximum angle of 30°. Calculate the height it reaches above its lowest point if the length of the pendulum is 2 m. **(PP)**

Working and Answer:
Height $h = L - L\cos(\theta), h = 2 - 2\cos(30°) = 2 - 2 \cdot \frac{\sqrt{3}}{2} = 2 - \sqrt{3} \approx$ 0.268 m. Answer: 0.268 m

7. A mass-spring system oscillates with a frequency of 1.5 Hz. If the mass is 0.8 kg, calculate the spring constant. **(PP)**

Working and Answer:
Frequency $f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}, k = (2\pi f)^2 m, k = (2\pi \cdot 1.5)^2 \cdot 0.8 \approx (9.42)^2 \cdot 0.8 \approx$ $88.8 \cdot 0.8 \approx 71.04\,\text{N/m}$. Answer: 71.04 N/m

8. A mass of 1 kg is attached to a spring with a spring constant of 50 N/m. Calculate the period of oscillation. **(PP)**

Working and Answer:
Period $T = 2\pi\sqrt{\frac{m}{k}}, T = 2\pi\sqrt{\frac{1}{50}} \approx 2\pi\sqrt{0.02} \approx 2\pi \cdot 0.141 \approx$ 0.886 s. Answer: 0.886 s

9. A mass-spring system has a total energy of 20 J and a spring constant of 100 N/m. Calculate the maximum displacement. **(PP)**

Working and Answer:
Total energy $E = \frac{1}{2}kA^2, 20 = \frac{1}{2} \cdot 100 \cdot A^2, A^2 = \frac{20 \cdot 2}{100} = \frac{40}{100} = 0.4, A = \sqrt{0.4} \approx$ 0.632 m. Answer: 0.632 m

10. A pendulum has a length of 3 m and swings with a small angle approximation. Calculate the frequency of the pendulum. **(PP)**

Working and Answer:
Frequency $f = \frac{1}{2\pi}\sqrt{\frac{g}{L}}, f = \frac{1}{2\pi}\sqrt{\frac{9.81}{3}} \approx \frac{1}{2\pi}\sqrt{3.27} \approx \frac{1}{2\pi} \cdot 1.81 \approx$ 0.29 Hz. Answer: 0.29 Hz

11. A mass-spring system oscillates with a frequency of 2 Hz and a mass of 0.5 kg. Calculate the spring constant. **(PPP)**

Working and Answer:
Frequency $f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}, k = (2\pi f)^2 m, k = (2\pi \cdot 2)^2 \cdot 0.5 \approx (12.57)^2 \cdot 0.5 \approx$ $158.1 \cdot 0.5 \approx 79.05\,\text{N/m}$. Answer: 79.05 N/m

12. A mass of 0.75 kg is attached to a spring with a spring constant of 150 N/m. Calculate the maximum potential energy stored in the spring when it is compressed by 0.1 m. **(PPP)**

Working and Answer:
Potential energy $PE = \frac{1}{2}kx^2, PE = \frac{1}{2} \cdot 150 \cdot (0.1)^2 = \frac{1}{2} \cdot 150 \cdot 0.01 =$ 0.75 J. Answer: 0.75 J

13. A pendulum has a length of 2.5 m and swings with a maximum angle of 45°. Calculate the maximum height above the lowest point. **(PPP)**

Working and Answer:
Height $h = L - L\cos(\theta), h = 2.5 - 2.5\cos(45°) = 2.5 - 2.5 \cdot \frac{\sqrt{2}}{2} = 2.5 - 1.77 \approx$ 0.73 m. Answer: 0.73 m

14. A mass-spring system oscillates with a total energy of 30 J and a spring constant of 200 N/m. Calculate the maximum displacement. **(PPP)**

Working and Answer:
Total energy $E = \frac{1}{2}kA^2, 30 = \frac{1}{2} \cdot 200 \cdot A^2, A^2 = \frac{30 \cdot 2}{200} = \frac{60}{200} = 0.3, A = \sqrt{0.3} \approx$ 0.547 m. Answer: 0.547 m

15. A mass of 1.2 kg is attached to a spring with a spring constant of 80 N/m. Calculate the period of oscillation. **(PPP)**

Working and Answer:
Period $T = 2\pi\sqrt{\frac{m}{k}}, T = 2\pi\sqrt{\frac{1.2}{80}} \approx 2\pi\sqrt{0.015} \approx 2\pi \cdot 0.122 \approx$ 0.766 s. Answer: 0.766 s

16. A mass-spring system has a frequency of 3 Hz and a mass of 1 kg. Calculate the spring constant. **(PPPP)**

Working and Answer:
Frequency $f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}, k = (2\pi f)^2 m, k = (2\pi \cdot 3)^2 \cdot 1 \approx (18.85)^2 \cdot 1 \approx$ 355.4 N/m. Answer: 355.4 N/m

17. A pendulum has a length of 4 m and swings with a small angle approximation. Calculate the frequency of the pendulum. **(PPPP)**

Working and Answer:
Frequency $f = \frac{1}{2\pi}\sqrt{\frac{g}{L}}, f = \frac{1}{2\pi}\sqrt{\frac{9.81}{4}} \approx \frac{1}{2\pi}\sqrt{2.4525} \approx \frac{1}{2\pi} \cdot 1.57 \approx$ 0.25 Hz. Answer: 0.25 Hz

18. A mass of 0.5 kg is attached to a spring with a spring constant of 120 N/m. Calculate the maximum speed if the amplitude is 0.15 m. **(PPPP)**

Working and Answer:
Maximum speed $v_{\max} = A \cdot \omega, \omega = 2\pi f = 2\pi\sqrt{\frac{k}{m}} = 2\pi\sqrt{\frac{120}{0.5}} \approx 2\pi \cdot 15.49 \approx 97.1\,\text{rad/s}, v_{\max} = 0.15 \cdot 97.1 \approx 14.57\,\text{m/s}$. Answer: 14.57 m/s

19. A mass-spring system oscillates with a total energy of 40 J and a spring constant of 250 N/m. Calculate the maximum displacement. **(PPPP)**

Working and Answer:
Total energy $E = \frac{1}{2}kA^2, 40 = \frac{1}{2} \cdot 250 \cdot A^2, A^2 = \frac{40 \cdot 2}{250} = \frac{80}{250} = 0.32, A = \sqrt{0.32} \approx 0.566\,\text{m}$. Answer: 0.566 m

20. A pendulum has a length of 5 m and swings with a maximum angle of 60°. Calculate the maximum height above the lowest point. **(PPPP)**

Working and Answer:
Height $h = L - L\cos(\theta), h = 5 - 5\cos(60°) = 5 - 5 \cdot 0.5 = 5 - 2.5 =$ 2.5 m. Answer: 2.5 m

21. A mass of 1.5 kg is attached to a spring with a spring constant of 300 N/m. Calculate the period of oscillation. **(PPPP)**

Working and Answer:
Period $T = 2\pi\sqrt{\frac{m}{k}}, T = 2\pi\sqrt{\frac{1.5}{300}} \approx 2\pi\sqrt{0.005} \approx 2\pi \cdot 0.071 \approx$ 0.446 s. Answer: 0.446 s

22. A mass-spring system oscillates with a frequency of 4 Hz and a mass of 0.2 kg. Calculate the spring constant. **(PPPPP)**

Working and Answer:
Frequency $f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}, k = (2\pi f)^2 m, k = (2\pi \cdot 4)^2 \cdot 0.2 \approx (25.13)^2 \cdot 0.2 \approx 632.5 \cdot 0.2 \approx 126.5\,\text{N/m}$. Answer: 126.5 N/m

23. A pendulum has a length of 6 m and swings with a small angle approximation. Calculate the frequency of the pendulum. **(PPPPP)**

Working and Answer:
Frequency $f = \frac{1}{2\pi}\sqrt{\frac{g}{L}}, f = \frac{1}{2\pi}\sqrt{\frac{9.81}{6}} \approx \frac{1}{2\pi}\sqrt{1.635} \approx \frac{1}{2\pi} \cdot 1.28 \approx 0.204\,\text{Hz}$. Answer: 0.204 Hz

24. A mass of 2 kg is attached to a spring with a spring constant of 400 N/m. Calculate the maximum speed if the amplitude is 0.2 m. **(PPPPP)**

Working and Answer:
Maximum speed $v_{\max} = A \cdot \omega, \omega = 2\pi f = 2\pi\sqrt{\frac{k}{m}} = 2\pi\sqrt{\frac{400}{2}} \approx 2\pi \cdot 14.14 \approx 88.9\,\text{rad/s}, v_{\max} = 0.2 \cdot 88.9 \approx 17.78\,\text{m/s}$. Answer: 17.78 m/s

25. A mass-spring system has a total energy of 60 J and a spring constant of 500 N/m. Calculate the maximum displacement. **(PPPPP)**

Working and Answer:
Total energy $E = \frac{1}{2}kA^2, 60 = \frac{1}{2} \cdot 500 \cdot A^2, A^2 = \frac{60 \cdot 2}{500} = \frac{120}{500} = 0.24, A = \sqrt{0.24} \approx 0.49\,\text{m}$. Answer: 0.49 m