Level 3 Physics: practice paper 2026

AS 91524 Demonstrate understanding of mechanical systems · Vertex Academy practice paper, not an NZQA paper

Attempt ALL the questions. Show ALL working. Write your answers on lined paper, or in the space under each question.

QUESTION ONE

(a) The International Space Station orbits 420 km above the Earth's surface. The Earth's mass is 5.97×10^{24} kg and its radius 6.37×10^{6} m. G = 6.67×10^{-11} N m² kg⁻².
Use $g = GM \div r^2$.
Calculate the gravitational field strength at the height of the space station.

(b) The space station orbits at $r = 6.79 \times 10^{6}$ m from the Earth's centre. GM for the Earth is 3.98×10^{14} N m² kg⁻¹.
Use $v = \sqrt{(GM \div r)}$.
Calculate the station's orbital speed.

(c) Astronauts on the space station ($r = 6.79 \times 10^6$ m, $v = 7.66 \times 10^3$ m s^{-1}) float as if weightless, even though the gravitational field there is 8.64 N kg^{-1}.
Use $T = 2\pi r \div v$.
Calculate the period of the orbit in minutes, and explain why the astronauts feel weightless.

(d) At a science show, a 2.0 kg bucket of water is swung in a vertical circle of radius 0.90 m.
Use $g = 9.81$ m s^{-2} and $F = mv^2 \div r$.
Calculate the smallest speed the bucket can have at the top without the water falling out, and explain why. At the bottom of the circle the bucket moves at 4.5 m s^{-1}. Calculate the tension in the rope there.

QUESTION TWO

(a) A wind turbine at a Manawatū wind farm turns at 15 revolutions per minute. Each blade is 40 m long.

Use $\omega = 2\pi f$ and $v = r\omega$.

Calculate the angular velocity of the blades and the speed of a blade tip.

(b) In a storm the turbine is braked. It slows steadily from 1.57 rad s^{-1} to rest in 30 s.

Use $\alpha = \Delta\omega \div t$.

Calculate its angular acceleration.

(c) The turbine's rotor has a rotational inertia of 4.0×10^6 kg m^2. It slows steadily from 1.57 rad s^{-1} to rest in 30 s ($\alpha = -0.0524$ rad s^{-2}).

Use $\tau = I\alpha$ and $\theta = ((\omega i + \omega f) \div 2) \times t$.

Calculate the braking torque and how many revolutions the rotor makes while stopping.

(d) A student sits on a spinning office chair holding a 2.0 kg weight in each hand at arm's length, 0.70 m from the axis. Without the weights, the student and chair have a rotational inertia of 1.8 kg m². They spin at 2.0 rad s^{-1} and then pull the weights in to 0.15 m from the axis. Treat the weights as point masses and ignore friction.

Use $I = mr^2$, $L = I\omega$ and $E_{k(rot)} = \frac{1}{2}I\omega^2$.

Calculate the new angular velocity. Show that the rotational kinetic energy increases, and explain where the extra energy comes from.

QUESTION THREE

(a) A 0.25 kg mass hangs on a spring with a spring constant of 40 N m^{-1} and bounces up and down.
Use $T = 2\pi\sqrt{(m \div k)}$.
Calculate the period of the oscillation.

(b) A swing in a Nelson playground hangs on chains 2.4 m long. A child swings with small oscillations.
Use $T = 2\pi\sqrt{(L \div g)}$ and $g = 9.81$ m s^{-2}.
Calculate the period of the swing.

(c) The 0.25 kg mass on the 40 N m^{-1} spring oscillates with an amplitude of 0.060 m.
Use $\omega = \sqrt{(k \div m)}$, $v_{max} = A\omega$ and $a_{max} = A\omega^2$.
Calculate the maximum speed and the maximum acceleration of the mass, and state where in the motion each one happens. Explain why.

(d) The mass on the spring ($\omega = 12.6$ rad s^{-1}, amplitude 0.060 m) is pulled down to its lowest point and released.

Use $y = A\cos\omega t$ and $v = A\omega\sin\omega t$ (measuring t from the release).

Calculate how long the mass takes to rise from its lowest point to 0.030 m below the equilibrium position, and its speed at that moment. Explain why this takes less than a quarter of the period, even though the mass has covered only half the distance to equilibrium.

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