Physics Test

Part A: Short Questions

Remarks:
- No aids (calculator, FoTa, formula sheet) allowed
- Always express numerical results as rounded decimal numbers (except in ratios)
- Derivation required for numerical results

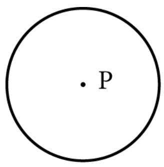
1. On the reverse side of the sheet, graph a resonance curve. Describe a real life phenomenon where resonance can be observed.
2. Which of the following statements are true?

   ☐ The kinetic energy oscillates at twice the pendulum's frequency.

   ☐ An oscillation's amplitude decreases fastest when it is critically damped.

   ☐ The magnetic field between two parallel, current-carrying wires is homogeneous.

   ☐ An electron flying parallel to a current-carrying wire experiences a force perpendicular to its direction.
3. A pendulum's spring is replaced by one whose elastic constant is 20 % greater. By what percentage does this change the pendulum's period?
4. A spring pendulum oscillates with amplitude 14 cm. At what displacement from the equilibrium position are the kinetic and the potential energy equal?
5. Choose the orientation of the current in the loop such that the magnetic field in P points into the sheet.



Numerical Solutions: 2. ☑ ☑ ☐ ☑; 3. - 9 %; 10 cm; 5. clockwise

Part B: Problems

Remarks:

- Write your solutions to the problems on the answer sheet. Start a new page for every problem.
- An algebraic solution and all values used in calculations are required to get the full mark.
- Results must be rounded to at most three significant figures.

1. A rod with length L is suspended on one end. For a small horizontal displacement x of the centre of mass from its equilibrium position we find the relation

$$m\,a_x = -\frac{3}{2}\,\frac{m\,g\,x}{L}.$$

   a) Show that the rod's motion is a simple harmonic motion with period

$$T = \sqrt{\frac{2}{3}}\,T_0$$

   where T_0 is the period of a mathematical pendulum with length L.

   b) A rod (65 ± 1) cm long oscillates with an amplitude of (3.4 ±0.1) cm. Calculate the maximum value of the rod's free end's velocity.

   Bonus: Calculate the absolute error for the velocity just calculated and write the result correctly rounded in the standard form ($v \pm \Delta v$).

2. The motion of a mass on a spring with frictional damping was analysed using a video recording (Byland, March 2008). The result is displayed in the diagram on the additional sheet.

   a) Read from the diagram – with a reasonable precision – the period of the oscillation. Calculate the signal's frequency and angular frequency.

   b) Mark in the diagram examples for the following conditions and label them: i) maximum velocity; ii) maximum acceleration; iii) maximum kinetic energy; iv) maximum total energy.

   c) Find a mathematical expression describing the damped oscillation. Determine numerical values for the additional parameters.

3. A pair of Helmholtz coils is used to produce a magnetic field. Each coil has 55 turns and a radius of (23 ± 1) cm. During the measurements a current of (1.42 ± 0.03) A is flowing through the coils.

   a) Calculate the magnitude of the magnetic field along the axis of the Helmholtz coils.

   Bonus: Determine the field's absolute error and write the result properly rounded and with correct units in the standard form ($B \pm \Delta B$).

   b) When the current through the first coil has the opposite direction of that in the second coil, the magnetic field along the axis is no longer homogeneous. Sketch its magnitude as a function of position for this case.

   c) Briefly discuss the advantages and disadvantages of Helmholtz coils over a solenoid.

Numerical Solutions: 1. (161 ± 6) mm/s; 2.0.97 s, 1.03 Hz, 6.5 rad/s; c) A_0 = 105 mm, damping coefficient 7.9 mm/s; 3. (310 ± 20) µT

Diagram for Problem 2