Queen Mary, University of London

MIDTERM EXAMINATION

MAS226 Dynamics of Physical Systems

09 Nov 2007, 15.10 - 15.50 (40 minutes)

This paper contains 5 questions. You should attempt ALL questions. Answer each one clearly and legibly, crossing out any false starts. Each question is worth 20 marks.

Calculators are NOT permitted in this examination.

1. Given the vectors, $\mathbf{A} = -xy\mathbf{i} + \mathbf{j}$ and $\mathbf{B} = -y\mathbf{i} + y^2\mathbf{j} + z\mathbf{k}$, and the three-dimensional gradient operator ∇, evaluate:

(a) $\mathbf{A}\cdot\mathbf{B}$ [5 marks]

(b) $\nabla\times\mathbf{A}$ [5 marks]

(c) $\nabla\cdot\nabla\times\mathbf{B}$ [10 marks]

2. A 0.1 kg ball is thrown directly upward with a speed of 30 m s^{-1} from a rooftop of a 100 m tall building. Assume gravity g is 10 m s^{-2} and neglect friction.

(a) How high will the ball go up (in meters), relative to the rooftop? [7 marks]

(b) For how long has the ball been up in the air (in seconds), when it comes back down to the rooftop height? [7 marks]

(c) How much kinetic energy (in Joules) will the ball have at the instant when it hits the ground (100 m below the rooftop)? [6 marks]

3. State briefly (i.e., in one or two sentences) the following. Use diagrams and labels as necessary to be clear:

(a) Newton's first law. [7 marks]

(b) Newton's universal gravitational law. [7 marks]

(c) One way the law in (b) *differs* from Coulomb's electrostatic law. [6 marks]

  [Next question overleaf.]

4. An one-dimensional potential function is given by $V(x) = -x(x-1)(x+1)$.

(a) Sketch $V(x)$ and find the equilibrium points $V(x)$. [10 marks]

(b) Determine whether the equilibrium points are stable or unstable. [5 marks]

(c) Indicate the direction of a test particle around the equilibrium points and at towards $-\infty$ and $+\infty$. [5 marks]

5. You are given the potential function, $U(x, y, z) = -U_0 \exp\{-(x^2 + y^2 + z^2)\}$.

(a) Compute the force $\mathbf{F}$ associated with the potential function. [7 marks]

(b) Is the computed force conservative? Why or why not? [7 marks]

(c) What is the minimum amount of energy needed to escape out from the center of this "potential well"? [6 marks]

[End of examination paper.]