The Open University Supplementary Material
S357 Space, Time and Cosmology

Course and assignment number:

Computer Marked Assignment

S357 41

Covering: **Units 3–6**

Cut-off date:
Friday 23 May 1997

Make sure you know how to use the CMA form: detailed instructions are given in your student handbook (or supplement).
You are strongly advised to attempt every question in this assignment.
If you do not wish to answer a question, pencil across the 'don't know' cell ('?').
If you think that a question is unsound in any way, pencil across the 'unsound' cell ('U') *in addition to* pencilling across either an answer cell or the 'don't know' cell.
Note For each question you **must** *pencil across* **either** *the required number of answer cells* **or** *the 'don't know' cell.*

PART A

Q1 Which of the statements about the principle of relativity in Newtonian mechanics given in the key are correct? Select no more than *two* items. Pencil across *two* cells in row 1.

KEY for Q1

A From the principle of relativity, it follows that two equally calibrated inertial reference frames that are related by a rotation in space are physically indistinguishable.

B From the principle of relativity, it follows that two equally calibrated rotating reference frames cannot be distinguished from one another.

C It is a consequence of the principle of relativity that a person who jumps off the top of a building and falls freely observes the same net force on any object as someone standing on the ground.

AF

D It is a consequence of the principle of relativity that if two inertial observers look at a given event, they must describe it in exactly the same way.

E According to the principle of relativity, the period of a given pendulum is exactly the same in an aircraft at a height of 13 km as on the ground, provided the velocity of the aircraft is constant.

F Newton's second law of motion and the law of universal gravitation are consistent with the principle of relativity.

Q2 to Q5 concern an encounter between two identical particles, A and B, comprising an isolated system. The positions and velocities of A and B are given relative to an inertial reference frame. The particles reach the point of their closest approach to each other at $t = t_0$, and at an instant long before t_0, when the potential energy of the system is negligible, A is at $(d, 0, -X)$ and has velocity $(0, 0, V)$, while B is at $(-d, 0, X)$ and has velocity $(0, 0, -V)$.

The key for Q2 to Q5 contains a number of proposals for the positions, $\mathbf{x}_A$ and $\mathbf{x}_B$, and velocities, $\mathbf{v}_A$ and $\mathbf{v}_B$, of the particles at an instant long after t_0, when the potential energy of the system is again negligible. Q4 and Q5 are double weighted questions.

Q2 Which proposal is inconsistent with the law of conservation of momentum? Pencil across *one* cell in row 2. E

Q3 Which proposal is inconsistent with the law of conservation of energy? Pencil across *one* cell in row 3. D

Q4 Which proposal is inconsistent with the law of conservation of angular momentum? Pencil across *one* cell in row 4. A

Q5 Which proposal is inconsistent with the consequence of the principle of relativity that 'symmetry begets symmetry'? Pencil across *one* cell in row 5.

E

KEY for Q2 to Q5

A

$$\mathbf{x}_A = \left(X - \frac{d}{\sqrt{2}}, 0, X - \frac{d}{\sqrt{2}}\right) \quad \mathbf{v}_A = \left(\frac{V}{\sqrt{2}}, 0, \frac{V}{\sqrt{2}}\right)$$
$$\mathbf{x}_B = \left(-X + \frac{d}{\sqrt{2}}, 0, -X + \frac{d}{\sqrt{2}}\right) \quad \mathbf{v}_B = \left(-\frac{V}{\sqrt{2}}, 0, -\frac{V}{\sqrt{2}}\right)$$

B

$$\mathbf{x}_A = \left(X - \frac{d}{\sqrt{2}}, 0, X - \frac{3d}{\sqrt{2}}\right) \quad \mathbf{v}_A = \left(\frac{V}{\sqrt{2}}, 0, \frac{V}{\sqrt{2}}\right)$$
$$\mathbf{x}_B = \left(-X - \frac{3d}{\sqrt{2}}, 0, -X - \frac{d}{\sqrt{2}}\right) \quad \mathbf{v}_B = \left(-\frac{V}{\sqrt{2}}, 0, -\frac{V}{\sqrt{2}}\right)$$

C

$$\mathbf{x}_A = \left(X + \frac{d}{\sqrt{2}}, 0, X - \frac{d}{\sqrt{2}}\right) \quad \mathbf{v}_A = \left(\frac{V}{\sqrt{2}}, 0, \frac{V}{\sqrt{2}}\right)$$
$$\mathbf{x}_B = \left(-X - \frac{d}{\sqrt{2}}, 0, -X + \frac{d}{\sqrt{2}}\right) \quad \mathbf{v}_B = \left(-\frac{V}{\sqrt{2}}, 0, -\frac{V}{\sqrt{2}}\right)$$

D

$$\mathbf{x}_A = \left(X + \frac{d}{2}, 0, X - \frac{d}{2}\right) \quad \mathbf{v}_A = (V, 0, V)$$
$$\mathbf{x}_B = \left(-X - \frac{d}{2}, 0, -X + \frac{d}{2}\right) \quad \mathbf{v}_B = (-V, 0, -V)$$

E

$$\mathbf{x}_A = (X + d, 0, X - d) \quad \mathbf{v}_A = \left(\frac{V}{2}, \frac{V}{\sqrt{2}}, \frac{V}{2}\right)$$
$$\mathbf{x}_B = (-X - d, 0, -X + d) \quad \mathbf{v}_B = \left(-\frac{V}{2}, \frac{V}{\sqrt{2}}, -\frac{V}{2}\right)$$

$J = (0, Vd, 0) + (0, Vd, 0) = 2Vd$