PART B

Q13 to Q22 mainly concern Unit 2.

Q13 Select from the key the *two* items that are *true* statements. Pencil across *two* cells in row 13.

KEY for Q13

A In Newtonian mechanics, all inertial frames are at rest in absolute space.

B In Newtonian mechanics, all frames that are at rest in an Earthbound laboratory are inertial.

C In Newtonian mechanics, it is possible to extend the axes of an inertial frame indefinitely.

D From the principle of relativity, it follows that two inertial frames that differ only by a rotation of axes are physically indistinguishable.

E From the principle of relativity, it follows that two inertial frames that differ only by a recalibration of axes are physically indistinguishable.

F From the principle of relativity, it follows that a frame rotating with uniform angular speed with respect to an inertial frame is also an inertial frame.

Q14 Select from the key the item that is a *true* statement. Pencil across *one* cell in row 14.

KEY for 14

A The principle of relativity applies only to free particles.

B The principle of relativity is invalidated by the observation that identically constructed pendulums swing with different periods on the surface of the Moon and of the Earth.

C The principle of relativity requires that animals of different sizes have different bone structures.

D The principle of relativity requires that kinetic energy be conserved in all collisions of particles.

E The physical content of the principle of relativity in Newtonian mechanics was first pointed out by Albert Einstein.

F None of items A–E is a true statement.

Q15 The key lists proposals for the magnitude of the acceleration of one particle (particle 1) as it interacts with another particle (particle 2) in all possible circumstances. Which *two* proposals are consistent with the principle of relativity? In the key, k is a positive constant, and $\mathbf{x}_1, \mathbf{v}_1$ and $\mathbf{x}_2, \mathbf{v}_2$ are the positions and velocities of the two particles. Pencil across *two* cells in row 15.

KEY for Q15

A $|\mathbf{a}_1| = k|\mathbf{x}_1^2 + 3\mathbf{x}_1 \cdot \mathbf{x}_2|$

B $|\mathbf{a}_1| = k|(\mathbf{x}_1 - \mathbf{x}_2)^2 + \mathbf{x}_1 \cdot \mathbf{x}_2|$

C $|\mathbf{a}_1| = k|\mathbf{x}_1 - 2\mathbf{x}_2|^2$

D $|\mathbf{a}_1| = k|\mathbf{x}_1^2 + \mathbf{x}_2^2 - 2\mathbf{x}_1 \cdot \mathbf{x}_2|$

E $|\mathbf{a}_1| = k|\mathbf{x}_1^2 + \mathbf{x}_2^2 + 2\mathbf{x}_1 \cdot \mathbf{x}_2|$

F $|\mathbf{a}_1| = k|(\mathbf{v}_1 - \mathbf{v}_2) \cdot (\mathbf{x}_1 + \mathbf{x}_2)|$

G $|\mathbf{a}_1| = k|\mathbf{v}_1 \cdot \mathbf{x}_1 + \mathbf{v}_2 \cdot \mathbf{x}_2|$

H $|\mathbf{a}_1| = k|\mathbf{x}_1 \cdot \mathbf{v}_1 + \mathbf{x}_2 \cdot \mathbf{v}_2 - \mathbf{x}_1 \cdot \mathbf{v}_2 - \mathbf{x}_2 \cdot \mathbf{v}_1|$

Q16 and Q17 share the same key. A free particle moves along a path which in a particular *non*-inertial frame S, is defined by the equation

$$\mathbf{x}(t) = (3t, -2, t + t^2)$$

where t is time.

Q16 What is the velocity of this particle is S? Select one option from the key. Pencil across *one* cell in row 16.

Q17 What is the acceleration of this particle in S? Select one option from the key. Pencil across *one* cell in row 17.

KEY for Q16 and Q17

A $(3, -2, 3)$
B $(3, 0, 1 + 2t)$
C $(3, 0, 4t)$
D $(0, 0, 2)$
E $(0, 0, 2t)$
F $(0, 0, 4)$
G $(0, -2, 0)$

Q18 Which of the position vectors in the key could describe in the same non-inertial frame S the motion of other free particles? Pencil across *no more than two* cells in row 18.

KEY for Q18

A $(0, 0, -t^2)$
B $(-3t, -2, 3t + t^2)$
C $(1 + 2t^2, 3t, -2)$
D $(-2, 1 + 2t^2, 3t)$
E $(2t^2, 0, 0)$
F $(3, 0, 1 + 4t)$
G $(-2, 3t, t^3/3)$

Q19 Suppose a free particle of mass 2 kg is observed to have an acceleration $(0, -2, 8t)$ in a certain non-inertial frame T (where distances are measured in metres and time in seconds). What force, in newtons, would need to be applied to the particle to make it move with uniform velocity relative to T? Select one option from the key. Pencil across *one* cell in row 19.

KEY for Q19

A $(0, 1, -4t)$
B $(0, 0, 8)$
C $(0, 0, -8)$
D $(0, 2, -8t)$
E $(0, -2, 8t)$
F $(0, -4, 16t)$
G $(0, 4, -16t)$

13) CD 14) 15) DH. 16) B 17) D
18) B 19) G

$F = ma$
$F = 2(0, -2, 8t)$
$= (0, -4, 16t)$.