Q6 At time t_0, two particles with masses m_1 and m_2 are at rest a distance d apart in an inertial reference frame. Assume that the particles interact with each other by gravitation and are far from all other matter. If u is the relative speed at some later time, select from the key an expression for u_1, the speed of the particle of mass m_1 at any time $t > t_0$. [*Hint*: use a conservation law]. Pencil across *one* cell in row 6.

KEY for Q6

A $u_1 = m_1 u/(m_1 + m_2)$

B $u_1 = (m_1 + m_2)u/m_1$

C ~~$u_1 = m_2 u/(m_1 + m_2)$~~

D $u_1 = (m_1 + m_2)u/m_2$

E ~~$u_1 = m_1 u/m_2$~~

F ~~$u_2 = m_2 u/m_1$~~

Q7 For the same particles as in Q6, select from the key the formula that represents the relative speed u at which they approach each other at time $t > t_0$ when they are distance $r < d$ apart. Pencil across *one* cell in row 7.

KEY for Q7

A $\sqrt{\dfrac{2Gm_1m_2}{(m_1+m_2)(d-r)}}$

B $\sqrt{G(m_1+m_2)(d-r)(1/d^2+1/r^2)}$

C $\sqrt{Gm_1m_2(d-r)(1/d^2+1/r^2)/(m_1+m_2)}$

D $\sqrt{2G(m_1+m_2)(1/r-1/d)}$

E $\sqrt{2Gm_1m_2(1/r-1/d)/(m_1+m_2)}$

F $\sqrt{2G(m_1+m_2)/(d-r)}$

G None of A–F

PART B

Q8 The average value of the radial component of the electric field on the surface of a sphere, S, of radius 0.3 m is $5 \times 10^6\,\mathrm{N\,C^{-1}}$. Select from the key the statement which is necessarily *true*. Pencil across *one* cell in row 8.

KEY for Q8

A ~~All the charges in S are positive.~~

B A single charge of 5×10^{-5} C is located at the centre of S.

C A single charge of 5×10^{-5} C is located somewhere in S.

D The total charge in the vicinity of S is 5×10^{-5} C, located partly inside and partly outside S.

E ~~The total charge~~ inside S is 5×10^{-5} C.

F None of the statements A to E is true.

Q9 and Q10 A charged particle when at the origin, O, of an inertial reference frame, moving with velocity $\mathbf{v}$, experiences an acceleration $\mathbf{a}$ due to the combined action of static electric and magnetic fields $\mathbf{E}$ and $\mathbf{B}$. When $\mathbf{v}$ is $(1,1,0)$, $\mathbf{a}$ is $(2,-1,0)$, when $\mathbf{v}$ is $(1,0,1)$, $\mathbf{a}$ is $(1,-1,0)$, and when $\mathbf{v}$ is $(0,1,1)$, $\mathbf{a}$ is $(2,0,0)$. All quantities are expressed in SI units.

Q9 What acceleration would the particle experience when at rest at O? Select one item from the key for Q9 and Q10. Pencil across *one* cell in row 9.

Q10 What acceleration would the particle experience when at O moving with velocity $(0,-1,0)$? Select one item from the key for Q9 and Q10. Pencil across *one* cell in row 10.

KEY for Q9 and Q10

A $(0,0,0)$

B $(1,0,0)$

C $(0,1,0)$

D $(0,0,1)$

E $(0,0,-1)$

F $(0,-1,0)$

G $(-1,0,0)$

H None of A–G

Q11 Which statement in the key is *true*? Pencil across *one* cell in row 11.

KEY for Q11

A ~~If~~ two charges of +2 C and −2 C are enclosed by a sphere, the radial component of the electric field at any point on the surface of the sphere is zero.

B Opposite sides of a rectangular loop of wire carrying a steady current attract each other.

C A charged particle moving in a straight line at right angles to a long straight wire carrying a steady current experiences no force.

D The principle of relativity implies that two inertial observers in relative motion will agree about the magnitude of the Lorentz force acting on a charged particle.

E The lines of magnetic field, B, begin and end on magnetic monopoles.

F An electromagnetic wave carries energy and linear momentum, but not angular momentum.

G None of the statements A to F is true.