1. (a) $F_{centrifugal} = m\Omega^2 x\ \hat{\mathbf{i}}\ +\ m\Omega^2 y\ \hat{\mathbf{j}}$ ..1+1

   (b) $F_{Coriolis}\ \ = 2m\Omega\dot{y}\ \hat{\mathbf{i}}\ -\ 2m\Omega\dot{x}\ \hat{\mathbf{j}}$ ..1+1

   (c) $\ddot{x} = \Omega^2 x\ +\ 2\Omega\dot{y}\qquad \ddot{y} = \Omega^2 y\ -\ 2\Omega\dot{x}$ ..1

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2. (a) $\dfrac{d^2u}{d\theta^2}\ +\ \dfrac{u}{4}\ =\ 0$ ..3

   (b) $r(\theta)\ =\ \dfrac{1}{A\sin\dfrac{\theta}{2} + B\cos\dfrac{\theta}{2}}\quad$ OR $\quad u(\theta)\ =\ A\sin\dfrac{\theta}{2} + B\cos\dfrac{\theta}{2}$ ..2

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3. (a) $f(r)\ \ =\ -\dfrac{12maK^2}{r^4}\qquad$ 2 marks for power law *i.e.* $\dfrac{1}{r^4}$ & 1 for co-efficient ..2+1

   (b) $E_{total}\ =\ 0\qquad$ (zero) ..2

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4. (a) Farthest distance is 35.28AU acceptable range : $34 - 37$ ..1

   (b) K.E. ratio $= 3457$ acceptable range : $3400 - 3600$ ..2

   (c) eccentricity $= 0.967$ acceptable range : $0.95 - 0.98$ ..2

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5. (a) Coriolis force has one component only : $f = -2m\Omega\cos\theta v_z = -2m\Omega\cos\theta(v_0 - gt)$

   Full marks if somebody writes acceleration instead of the force, or skips the negative sign. ..1

   (b) Horizontal velocity on landing is 0 (zero). ..2

   (c) displacement is $\dfrac{4\Omega\cos\theta {v_0}^3}{3g^2}$ to the WEST. ..1.5+0.5

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6. (a) Speed of rocket relative to $S\ \ =\ \dfrac{1}{1 + \dfrac{v^2}{c^2}}2v$ ..2

   (b) Speed of payload relative to $S\ \ =\ \dfrac{1 + \dfrac{v^2}{3c^2}}{1 + \dfrac{3v^2}{c^2}}3v\ \equiv\ \dfrac{3c^2 + v^2}{c^2 + 3v^2}v$ ..3

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7. (a) $u'_x = \dfrac{2 - \sqrt{2}}{2\sqrt{2} - 1}c \approx 0.32c\ :\ u'_y = \dfrac{\sqrt{3}}{2\sqrt{2} - 1}c \approx 0.95c\qquad$ either answer ok ..1.5 + 1.5

   (b) $\tan\phi = 2.957 \rightarrow \phi \approx 71.32^o$ acceptable range : $68 - 73$ ..1

   (c) ${u'_x}^2 + {u'_y}^2\ =\ c^2$ exact answer only ..1

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8. (a) Time of crossing in S frame $= \dfrac{L_0\sqrt{1 - \beta^2}}{u}$ exact answer only ..2

   (b) Time of crossing in train's frame $= \dfrac{L_0}{u}$ exact answer only ..3
