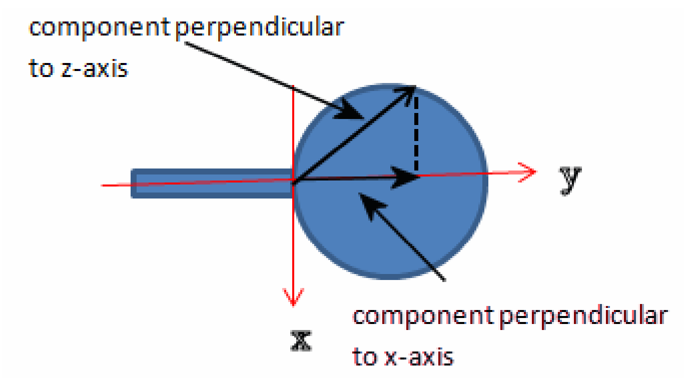
Problem 1: (D)
Relativistic energy: $E^2 = p^2c^2 + m^2c^4$, $p^2c^2 = (10^4 - 1)m^2c^4$, $pc \sim 100\ mc^2$.

Problem 2: (B)
Energy and momentum conservation:
$Mc^2 = (m^2c^4 + p^2c^2)^{1/2} + pc$, $M^2c^4 - 2Mpc^3 = m^2c^4$, $p = (M^2 - m^2)c/(2m)$

Problem 3: (B)
Length contraction: $L' = L/\gamma$, $\gamma = (1 - 0.64)^{-1/2} = 1/0.6$. $t = (0.6\ m)/(0.8*3*10^8\ m/s) = 2.5\ ns$

Problem 4: (D)
Moment of inertia about an axis: $I = \sum m_i r_i^2$ I_y is the smallest



Problem 5: (D)
Hamilton's equations of motion: $\dot{q}_i = \frac{\partial H}{\partial p_i}$, $\dot{p}_i = -\frac{\partial H}{\partial q_i}$

Problem 6: (D)
The Lagrangian L = T – U: $T = ½M\dot{X}^2 + ½m(\dot{X} + \dot{x})^2$, $U = ½kx^2$.

Problem 7: (C)
Relativistic energy: $E^2 = p^2c^2 + m^2c^4 = 16\ m^2c^4$, $p^2c^2 = 15\ m^2c^4$, $pc = 15^{1/2}\ mc^2$.

Problem 8: (A)
Conservation of angular momentum: A central force conserves angular momentum. Kepler's second law is a statement of angular momentum conservation.

Problem 9: (B)
Length contraction and velocity addition: $L' = L/\gamma$, $1/\gamma = 0.6 = (1 - v^2/c^2)^{1/2}$, v = 0.8 c is the speed of one spaceship with respect to the other.
$0.8\ c = (v' + v')/(1 + v'^2/c^2)$. $0.8 + 0.8\ v'^2/c^2 = 2\ v'/c$. $v'/c = 0.5$

Problem 10: (B)
Transformation of the electromagnetic fields

Problem 11: (C)

Time dilation: $t = \gamma\tau$. $\gamma = (1 - v^2/c^2)^{-1/2}$, $\gamma = 5/3$, $t = (11/3)*10^{-6}$ s.

$d = (4/5)*3*10^8$ m/s * $(11/3)*10^{-6}$s = $(44/5)*10^2$ m

Problem 12: (E)

Cyclic coordinates: The coordinate φ is cyclic, p_φ is a constant of motion.

Problem 13: (D)

The Lagrangian L = T – U: $T = ½m(dr/dt)^2 + ½mr^2(d\theta/dt)^2$, $U = ½k(r-s)^2$

Problem 14: (C)

The Lorentz transformation:

In the frame O let event 1 have space-time coordinates x = 0, t = 0, and event 2 have space-time coordinates x = 10 m, t = 0. In O' let event 1 have t' = 0 and event 2 have t' = -13 ns.

The Lorentz transformation for event 2 gives $ct' = \gamma ct - \gamma\beta x$, $c*1.3*10^{-8}$ s = $\gamma\beta*10$ m, $\gamma\beta = 0.39$.

$\beta = 0.39/(1 + 0.39^2)^{1/2} = 0.36$.

Problem 15: (A)

Kinematics: All quantities are given in the reference frame of the observer.