Problem 1: (B)

Kinematics: **a** has no component in the plane of the paper, $\mathbf{v} = \mathbf{v}_{initial} + \mathbf{v}_{perp}$ = constant.

Problem 2: (D)

Kinematics: $y = \frac{1}{2} gt^2 = 4.9*4$ m = 19.6 m

Problem 3: (D)

Hooke's law: $W = \frac{1}{2} k_1 x^2$, $2W = \frac{1}{2} k_2 (x/2)^2$, $k_2 = 8 k_1$.

Problem 4: (E)

Kepler's laws

Problem 5: (B)

Hooke's law: $\frac{1}{2} ks^2 = \frac{1}{2} mv^2$

Problem 6: (C)

Elastic collision, energy conservation: $\frac{1}{2} Mv_1^2 + \frac{1}{2} Mv_2^2 = \frac{1}{2} Mv^2$, : $v_1^2 + v_2^2 = v^2$.

Problem 7: (D)

Circular motion, angular momentum: $L = mRv = mR*(2\pi R/T)$, L is proportional to m/T.

Problem 8: (E)

The gravitational field outside a spherical mass distribution of total mass M is given by $F/m = GM/R^2$, pointing radially towards the center of M.

Problem 9: (B)

Energy conservation, rolling: $\frac{1}{2} Mv^2 + \frac{1}{2} Iv^2/R^2 = Mgh$, $Mv^2 + \frac{1}{2} MR^2 v^2/R^2 = 2Mgh$, $v^2 + \frac{1}{2} v^2 = 2gh$.

Problem 10: (D)

Kinematics, vector addition: $v^2_{north} + v^2_{east} = v^2$, $900\ (km/h)^2 + v^2_{north} = 40000\ (km/h)^2$, $v^2_{north} = 39100\ (km/h)^2$. t = 500/sqrt(39100)

Problem 11: (C)

Small oscillations: $f = sqrt(k/m)/(2\pi)$, $f_2/f_1 = sqrt(k_2 m_1/(k_1 m_2)) = sqrt(2/8) = 1/2$

Problem 12: (B)

Newton's 2nd law: $F = m_{total}*a$, $F_{12} = m_2*a$, $F_{12}/F = m_{total}/m_2$.

Problem 13: (A)

Newton's 2nd law: The force of static friction accelerates block B, $f = 10\ kg*2\ m/s^2$.

Problem 14: (C)

Motion in an acceleration frame, a simple pendulum: The apparent weight $F_g = mg' = m(g + a)$
$T = 2\pi\ sqrt(l/g')$.

Problem 15: (E)

Newton's 2nd law: $v = \omega r$, $f_{tangential} = mr\alpha$, $f_{radial} = m\omega^2 r$, $\tan\theta = f_{tangential}/f_{radial} = \alpha/\omega^2$.