Physics 2314, Formula sheet for Final

Kinematics

Particle under constant velocity:
\[ x = x_i + v_x t \]
\[ y = y_i + v_y t \]

Particle under constant acceleration:
\[ v_x = v_{xi} + a_x t \]
\[ v_y = v_{yi} + a_y t \]
\[ x = x_i + v_{xi} t + \frac{1}{2}a_x t^2 \]
\[ y = y_i + v_{yi} t + \frac{1}{2}a_y t^2 \]
\[ v_x^2 = v_{xi}^2 + 2a_x(x - x_i) \]
\[ v_y^2 = v_{yi}^2 + 2a_y(y - y_i) \]

Uniform circular motion: centripetal acceleration \( a = \frac{v^2}{r} = \omega^2 r \)
\( v = \omega r \)

Laws of motion

2nd Newton’s law: net force \( \mathbf{F} = ma \)

Weight: \( \mathbf{F}_g = mg \)
Normal force: \( \mathbf{N} \) (perpendicular to the surface)
Tension force: \( \mathbf{T} \) (along the cord)
Friction force: \( F_s \leq \mu_s N \) (static), \( F_k = \mu_k N \) (kinetic)

Work and energy

Work done by a force: \( W = \int \mathbf{F} \, dr \)

Kinetic energy: translational \( K = \frac{1}{2}mv^2 \), rotational \( K = \frac{1}{2}I\omega^2 \)

Potential energy: gravitaion \( U = mgy \), spring \( U = \frac{1}{2}kx^2 \)
Conservation of energy (conservative forces only): \( K_i + U_i = K_f + U_f \)
Conservation of energy (general): \( K_i + U_i = K_f + U_f + W_{\text{noncon}} \)

Rotation

Constant angular acceleration:
\[ \omega_f = \omega_i + \alpha t \]
\[ \theta_f = \theta_i + \omega_i t + \frac{1}{2}\alpha t^2 \]
\[ \omega_f^2 = \omega_i^2 + 2\alpha(\theta_f - \theta_i) \]

Moment of inertia:
\[ I = \sum m_i r_i^2 \] (discrete)
\[ I = \int r^2 \, dm \] (continuous)

Parallel-axis theorem:
\[ I = I_{CM} + MD^2 \]

Angular momentum: \( \mathbf{L} = \mathbf{r} \times \mathbf{p} \), \( L = I\omega \)
Torque: \( \tau = \mathbf{r} \times \mathbf{F} \), \( \tau = I\alpha \)

Universal gravitation: \( F = G\frac{m_1m_2}{r^2} \)

Useful constants

Gravitational acceleration \( g = 9.80 \text{ m/s}^2 \)
Gravitational constant \( G = 6.674 \times 10^{-11} \text{ N} \cdot \text{m}^2/\text{kg}^2 \)