Choosing mechanics principles (no fluids)

Typical inspirations		
Time(s)	t_i and t_f	
System size(s)	Point-like (bubble + dot)	Point-like (bubble + dot) Extended (bubble)
Axes	xy	AOR
Purpose(s)	Predict motion	
Mathematical attentiveness	Keep track of signs and directions	
Type of modeling	**Kinematics**	
Typical categories	**Linear motion**	**Rotational motion**
Typical starting recipes	Always true: $x_i + v_{x,\text{AVG}}\Delta t = x_f$ $v_{x,i} + a_{x,\text{AVG}}\Delta t = v_{x,f}$ 1st check for constant a_x: $x_i + v_{x,i}\Delta t + \frac{1}{2}a_x\Delta t^2 = x_f$ $v_{x,i}^2 + 2a_x\Delta x = v_{x,f}^2$ For SHM, $a_x = -\omega_{\text{SHM}}^2 x$	Always true: $\theta_i + \omega_{\text{AVG}}\Delta t = \theta_f$ $\omega_i + \alpha_{\text{AVG}}\Delta t = \omega_f$ 1st check for constant α: $\theta_i + \omega_i\Delta t + \frac{1}{2}\alpha\Delta t^2 = \theta_f$ $\omega_i^2 + 2\alpha\Delta\theta = \omega_f^2$ For SHM, $\alpha = -\omega_{\text{SHM}}^2\theta$
Typical organizing layouts	Motion diagram $t_i =$ $x_i =$ | $y_i =$ $v_{x,i} =$ | $v_{y,i} =$ $t_i < t < t_f$ $a_x =$ | $a_y =$ $t_f =$ $x_f =$ | $y_f =$ $v_{x,i} =$ | $v_{y,i} =$ x-t plot, v_x-t plot, a_x-t plot	Rotational motion diagram $t_i =$ $\theta_i =$ $\omega_i =$ $t_i < t < t_f$ $\alpha =$ $t_f =$ $\theta_f =$ $\omega_f =$ θ-t plot, ω-t plot, α-t plot
Typical follow-up recipes	$v_{x,\text{AVG}} = \frac{\Delta x}{\Delta t}$ $\quad v_x = \frac{\Delta x}{\Delta t_{\text{BRIEF}}}$ $a_{x,\text{AVG}} = \frac{\Delta v_x}{\Delta t}$ $\quad a_x = \frac{\Delta v_x}{\Delta t_{\text{BRIEF}}}$	$\omega_{\text{AVG}} = \frac{\Delta\theta}{\Delta t}$ $\quad \omega = \frac{\Delta\theta}{\Delta t_{\text{BRIEF}}}$ $\alpha_{\text{AVG}} = \frac{\Delta\omega}{\Delta t}$ $\quad \alpha = \frac{\Delta\omega}{\Delta t_{\text{BRIEF}}}$
	Go from plot to plot, left-to-right: Use tangent slope Go from plot to plot, right-to-left: Use signed area between curve and t axis $T_{\text{SHM}} = \frac{2\pi}{\omega_{\text{SHM}}}$ $\qquad f = \frac{1}{T}$	

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<table>
<tr><th colspan="4">Typical inspirations</th></tr>
<tr><td>Time(s)</td><td colspan="3">t</td></tr>
<tr><td>System size(s)</td><td colspan="2">Point-like (bubble + dot)</td><td>Point-like (bubble + dot)
Extended (rigid, bubble)</td></tr>
<tr><td>Axes</td><td>xy</td><td>$+\text{in}$ and $+\tan$</td><td>AOR</td></tr>
<tr><td>Purpose(s)</td><td colspan="3">Explain contributions</td></tr>
<tr><td>Mathematical attentiveness</td><td colspan="3">Keep track of signs and directions</td></tr>
<tr><td>Type of modeling</td><td colspan="3">Dynamics</td></tr>
<tr><td>Typical categories</td><td>Forces
(linear dynamics)</td><td>Forces
(circular motion)</td><td>Torques
(rotational dynamics)</td></tr>
<tr><td>Typical starting recipes</td><td>$a_x = \frac{\sum F_x}{m_\mathrm{I}}$
N2L</td><td>$a_\mathrm{IN} = \frac{\sum F_\mathrm{IN}}{m_\mathrm{I}}$
N2L</td><td>$\alpha = \frac{\sum \tau}{I}$
N2L for rotational motion</td></tr>
<tr><td>Typical organizing layouts</td>
<td>Force diagram

Cartesian force components chart
<table>
<tr><th>Force</th><th>F_x</th><th>F_y</th></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>$\sum F$</td><td></td><td></td></tr>
</table></td>
<td>Force diagram

Inward (and tangential) force components chart
<table>
<tr><th>Force</th><th>F_IN</th><th>F_TAN</th></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>$\sum F$</td><td></td><td></td></tr>
</table>
(Often don't need F_TAN column)</td>
<td>Force diagram with forces originating from points of application

Force and torque chart
<table>
<tr><th>Force</th><th>F_x</th><th>F_y</th><th>$r_\perp$</th><th>F</th><th>τ</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>$\sum F$</td><td></td><td></td><td>\</td><td>\</td><td></td></tr>
</table></td></tr>
<tr><td rowspan="2">Typical follow-up recipes</td><td></td><td>$a_\mathrm{IN} = \frac{v^2}{r}$</td><td>$\tau = r_\perp F$
$r_\perp = r \sin\theta$ is the distance of closest approach on the line of action of the force of interest
$I = \sum m r_i^2$</td></tr>
<tr><td colspan="3">Gravitational attractions:
$F_{\mathrm{G,E}\to\mathrm{SYS}} = m_{\mathrm{G,SYS}}\, g$
$F_{G,1\to 2} = G\frac{m_1 m_2}{r_{12}^2}$
$F_{\mathrm{N,SUR}\to\mathrm{SYS}}$ corresponds to a ⊥ press
$F_{\mathrm{T,STRING}\to\mathrm{SYS}}$ corresponds to a pull
Kinetic friction force opposes occurring slippage:
$f_{\mathrm{K,SUR}\to\mathrm{SYS}} = \mu_{\mathrm{K,SUR\&SYS}} F_{\mathrm{N,SUR}\to\mathrm{SYS}}$
Static friction force opposes threatened slippage:
$f_{\mathrm{S,SUR}\to\mathrm{SYS}} \le f_{\mathrm{S,SUR}\to\mathrm{SYS}}^{\mathrm{MAX}} = \mu_{\mathrm{S,SUR\&SYS}} F_{\mathrm{N,SUR}\to\mathrm{SYS}}$</td></tr>
</table>

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Typical inspirations

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<tr><td>Time(s)</td><td colspan="3">t_i and t_f</td></tr>
<tr><td>System size(s)</td><td colspan="3">Point-like (bubble + dot)
Extended (bubble)</td></tr>
<tr><td>Axes</td><td>xy</td><td>AOR</td><td>xy
AOR</td></tr>
<tr><td>Purpose(s)</td><td colspan="3">Explain contributions</td></tr>
<tr><td>Mathematical attentiveness</td><td colspan="2">Keep track of signs and directions</td><td>Work mostly with scalars</td></tr>
<tr><td>Type of modeling</td><td colspan="3">Conservation laws</td></tr>
<tr><td>Typical categories</td><td>Impulse-momentum</td><td>Angular impulse-angular momentum</td><td>Work-Energy</td></tr>
<tr><td>Typical starting recipes</td><td>$\sum p_{i,x} + \sum J_x = \sum p_{f,x}$
Impulse-momentum theorem</td><td>$\sum L_i + \sum \tau_{\text{AVG}} \Delta t = \sum L_f$
Angular impulse-angular momentum theorem</td><td>$K_i + U_{\text{G},i} + U_{\text{S},i} + W = K_f + U_{\text{G},f} + U_{\text{S},f} + \Delta U_{\text{INT}}$
Generalized work-energy principle</td></tr>
<tr><td>Typical organizing layouts</td><td>Momentum bar chart

Momentum vector diagram

Momentum components chart</td><td>Angular-momentum bar chart</td><td>Energy bar chart</td></tr>
<tr><td rowspan="2">Typical follow-up recipes</td><td>$p_x = mv_x$

$J_x = F_{\text{AVG},x} \Delta t$
$J_x =$ Area between F_x-t plot and t axis</td><td>$L_{\text{PARTICLE},\circlearrowleft} = \pm mvr_\perp$
$L_\circlearrowleft = \pm I\omega$
$I = \sum m r_i^2$

$\sum \tau_{\text{AVG}} \Delta t =$ Area between $\sum \tau$-t plot and t axis</td><td rowspan="2">$K_{\text{PARTICLE}} = \frac{1}{2} mv^2$ $K_{\substack{\text{FIXED}\\\text{SKEWER}}} = \frac{1}{2} I\omega^2$
$K_{\substack{\text{RIGID}\\\text{EXTENDED}}} = \frac{1}{2} Mv_{\text{COM}}^2 + \frac{1}{2} I_{\substack{\text{ABOUT}\\\text{COM}}} \omega^2$

$U_{\text{G,E\&SYS}} = m_{\text{G,SYS}} gh$ $U_S = \frac{1}{2} k \Delta x^2$
$U_{\text{G},1\&2} = -G \frac{m_1 m_2}{r_{12}}$ $\Delta U_F = -W_F$

$W = (F \cos\theta)_{\text{AVG}} d$
$W_{F_x} =$ Area between F_x-x plot and x axis
$W_\tau = \tau_{\text{AVG}} \Delta\theta$
$W_\tau =$ Area between τ-θ plot and θ axis

$W = P_{\text{AVG}} \Delta t$ $P = (F \cos\theta) v$
$P_{\text{AVG}} = \frac{W}{\Delta t}$ $P = \tau\omega$

ΔU_{INT} doesn't have a memory formula</td></tr>
<tr><td colspan="2">$Mx_{\text{COM}} = m_1 x_1 + m_2 x_2 + \cdots + m_N x_N$
$Mv_{\text{COM},x} = m_1 v_{1,x} + m_2 v_{2,x} + \cdots + m_N v_{N,x}$
$Ma_{\text{COM},x} = m_1 a_{1,x} + m_2 a_{2,x} + \cdots + m_N a_{N,x}$</td></tr>
</table>