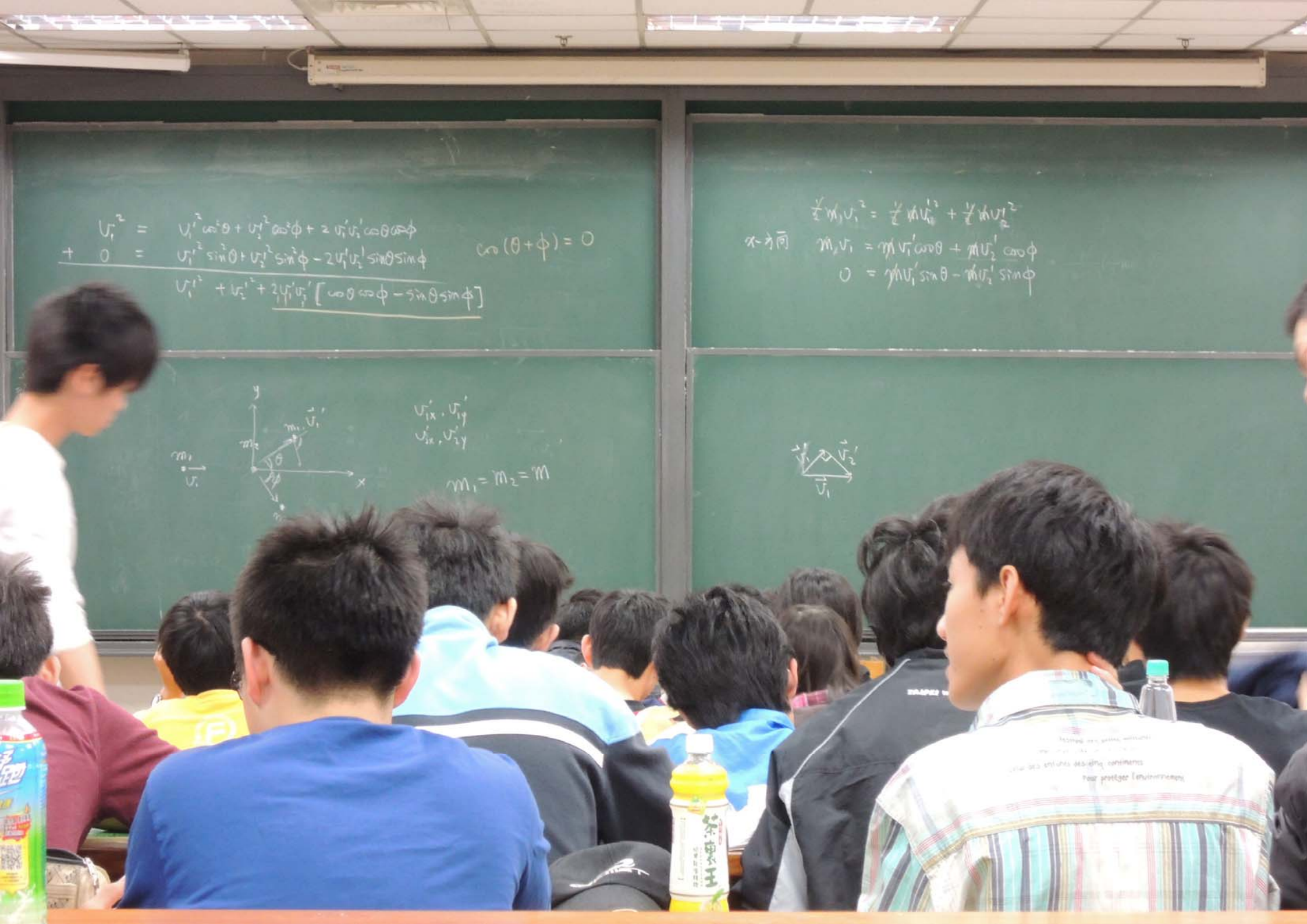
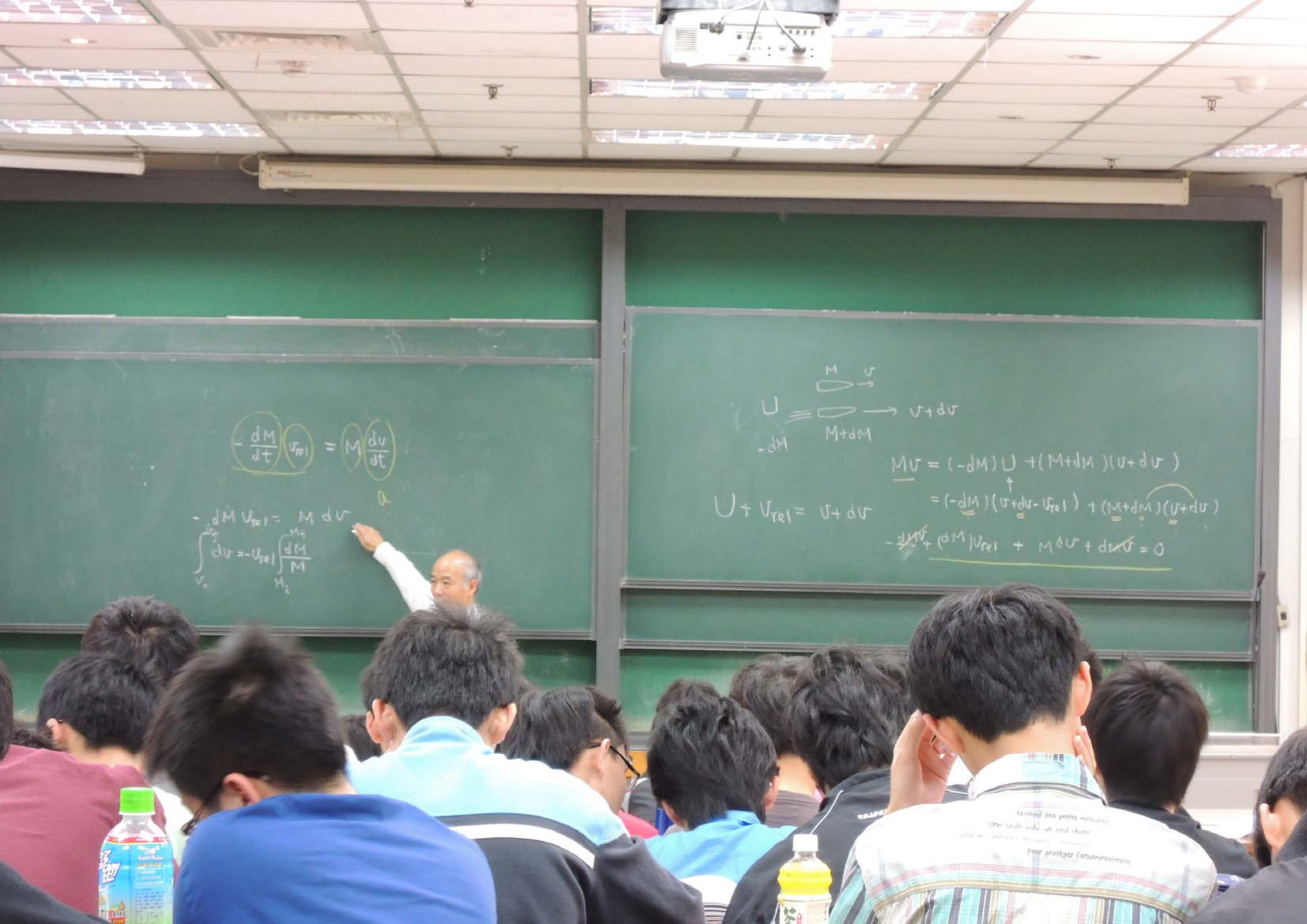

$v_1^2 = v_1'^2\cos^2\theta + v_2'^2\cos^2\phi + 2v_1'v_2'\cos\theta\cos\phi$
$+ \quad 0 = v_1'^2\sin^2\theta + v_2'^2\sin^2\phi - 2v_1'v_2'\sin\theta\sin\phi$
$\cos(\theta+\phi) = 0$
$v_1'^2 + v_2'^2 + 2v_1'v_2'[\cos\theta\cos\phi - \sin\theta\sin\phi]$
$\frac{1}{2}m_1v_1^2 = \frac{1}{2}mv_1'^2 + \frac{1}{2}mv_2'^2$
x方向
$m_1v_1 = mv_1'\cos\theta + mv_2'\cos\phi$
$0 = mv_1'\sin\theta - mv_2'\sin\phi$
v_{1x}', v_{1y}'
v_{2x}', v_{2y}'
$m_1 = m_2 = m$
m_1
v_1
$m_1, \vec{v}_1'$
m_2
θ
ϕ
x
y
$\vec{v}_1$
$\vec{v}_2'$


$-\frac{dM}{dt}(v_{rel}) = M\frac{dv}{dt}$
$-dM\,v_{rel} = M\,dv$
$\int_{v_0}^{v_f} dv = -v_{rel}\int_{M_1}^{M_2}\frac{dM}{M}$
M v
U
v+dv
-dM
M+dM
$Mv = (-dM)U + (M+dM)(v+dv)$
$= (-dM)(v+dv-v_{rel}) + (M+dM)(v+dv)$
$U + v_{rel} = v + dv$
$-dM\,v + (dM)v_{rel} + M\,dv + dM\,dv = 0$