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$$P = \frac{\partial L}{\partial \dot{x}} = \frac{\partial E_k}{\partial \dot{x}} = (m_1+m_2)\frac{dx}{dt}, \quad \frac{dx}{dt} = \frac{P}{m_1+m_2}$$

$$H = \frac{p^2}{2(m_1+m_2)} - (m_1-m_2)gx$$

$$\frac{dx}{dt} = \frac{\partial H}{\partial P} = \frac{H}{m_1+m_2} \qquad \frac{dP}{dt} = -\frac{\partial H}{\partial x} = (m_1-m_2)g$$

$$\frac{d^2x}{dt^2} = \frac{m_1-m_2}{m_1+m_2}g$$

$$)^2 + m_1 g x + m_2 g y$$

$$y \;\; 2 = -\frac{d^2x}{dt^2}$$

$$= m_1\frac{d^2x}{dt^2}$$

$$= m_2\frac{d^2y}{dt^2}$$

$$x + y + \pi R = l, \quad y = -x$$

$$E_k = \frac{1}{2}m_1\left(\frac{dx}{dt}\right)^2 + \frac{1}{2}m_2($$

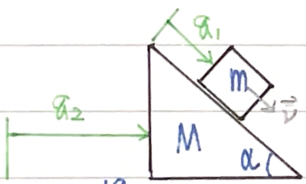
$$U = -m_1 g x - m_2 g y \qquad = -(m_1-m_2)gx + \text{constant}$$

$$L = E_k - U \qquad = \frac{1}{2}(m_1+m_2)\left(\frac{dx}{dt}\right)^2 + (m_1-m_2)gx$$

$$\frac{\partial L}{\partial x} = \frac{d}{dt}\frac{\partial L}{\partial \dot{x}}, \quad (m_1-m_2)g = (m_1+m_2)\frac{dx^2}{dt^2}, \quad \frac{dx^2}{dt^2} = \frac{m_1-m_2}{m_1+m_2}g$$ elaldly measure for g

case II a block sliding on a wedge

$$\left(\frac{dq_1}{dt}\right)^2\cos^2\alpha + \left(\frac{dq_2}{dt}\right)^2 + 2\frac{dq_1}{dt}\cos\alpha\frac{dq_2}{dt} + \left(\frac{dq_1}{dt}\right)^2\sin^2\alpha$$



$$T_M = \frac{1}{2}M\frac{dq_2}{dt} \qquad \vec{v} = (v_x, v_y) = \left(\frac{dq_1}{dt}\cos\alpha + \frac{dq_2}{dt}, \frac{dq_1}{dt}\sin\alpha\right)$$

$$T_m = \frac{1}{2}m(v_x^2+v_y^2) = \frac{1}{2}m\left[\left(\frac{dq_1}{dt}\right)^2 + \left(\frac{dq_2}{dt}\right)^2 + 2\frac{dq_1}{dt}\frac{dq_2}{dt}\cos\alpha\right]$$

$$T = T_m + T_M \qquad = \frac{1}{2}(M+m)\left(\frac{dq_2}{dt}\right)^2 + \frac{1}{2}m\left[\left(\frac{dq_1}{dt}\right)^2 + 2\frac{dq_1}{dt}\frac{dq_2}{dt}\cos\alpha\right]$$

$$U = -mgq_1\sin\alpha$$

$$L = E_k - U = \frac{1}{2}(M+m)\left(\frac{dq}{dt}\right)^2 + \frac{1}{2}m\left[\left(\frac{dq_1}{dt}\right)^2 + 2\frac{dq_1}{dt}\frac{dq_2}{dt}\cos\alpha\right] + mgq_1\sin\alpha$$

$$\frac{\partial L}{\partial q_2} = \frac{d}{dt}\frac{\partial L}{\partial \dot{q}_2}$$

$$M\frac{dq_2}{dt} + m\left(\frac{dq_2}{dt} + \frac{dq_1}{dt}\cos\alpha\right) = \text{constant}$$

$$\frac{d^2q_2}{dt^2} = -\frac{m}{M+m}\frac{d^2q_1}{dt^2}\cos\alpha$$

$$\frac{d^2q_1}{dt^2} = \frac{g\sin\alpha}{1-\frac{m\cos^2\alpha}{M+m}}$$

$$\frac{\partial L}{\partial q_1} = \frac{d}{dt}\frac{\partial L}{\partial \dot{q}_1}$$

$$mg\sin\alpha = \frac{d}{dt}\left[m\left(\frac{dq_1}{dt} + \frac{dq_2}{dt}\cos\alpha\right)\right]$$

$$= m\left(\frac{d^2q_1}{dt^2} + \frac{d^2q_2}{dt^2}\cos\alpha\right)$$

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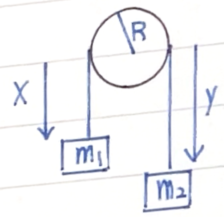
case I Atwood's machine



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$$L = \frac{1}{2} m_1 \left(\frac{dx}{dt}\right)^2 + \frac{1}{2} m_2 \left(\frac{dy}{dt}\right)^2 + m_1 g x + m_2 g y$$

$f(x,y) = x + y = \text{constant}$ $\qquad \frac{d^2y}{dt^2} = -\frac{d^2x}{dt^2}$

$\frac{\partial L}{\partial x} + \lambda \frac{\partial f}{\partial x} = \frac{d}{dt}\frac{\partial L}{\partial \dot{x}}$ $\qquad m_1 g + \lambda = m_1 \frac{d^2x}{dt^2}$

$\frac{\partial L}{\partial y} + \lambda \frac{\partial f}{\partial y} = \frac{d}{dt}\frac{\partial L}{\partial \dot{y}}$ $\qquad m_2 g + \lambda = m_2 \frac{d^2y}{dt^2}$

$\frac{d^2x}{dt^2} = \frac{(m_1 - m_2) g}{m_1 + m_2}$ $\qquad \lambda = -T$

$x + y + \pi R = l$, $y = -x$

$E_K = \frac{1}{2} m_1 \left(\frac{dx}{dt}\right)^2 + \frac{1}{2} m_2 ($

$U = -m_1 g x - m_2 g y$

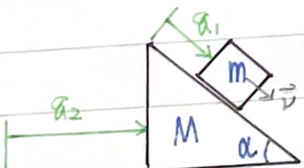
$L = E_K - U$

$= \frac{1}{2}(m_1 + m_2)\left(\frac{dx}{dt}\right)^2 + (m_1 - m_2) g x$

$\frac{\partial L}{\partial x} = \frac{d}{dt}\frac{\partial L}{\partial \dot{x}}$, $(m_1 - m_2) g = (m_1 + m_2)\frac{dx^2}{dt^2}$, $\frac{dx^2}{dt^2} = \frac{m_1 - m_2}{m_1 + m_2} g$ clearly measure for g

case II a block sliding on a wedge

$\left(\frac{dq_1}{dt}\right)^2 \cos^2\alpha + \left(\frac{dq_2}{dt}\right)^2 + 2\frac{dq_1}{dt}\cos\alpha\frac{dq_2}{dt} + \left(\frac{dq_1}{dt}\right)^2 \sin^2\alpha$



$T_M = \frac{1}{2} M \frac{dq_2}{dt}$ $\qquad \vec{v} = (v_x, v_y) = \left(\frac{dq_1}{dt}\cos\alpha + \frac{dq_2}{dt}, \frac{dq_1}{dt}\sin\alpha\right)$

$T_m = \frac{1}{2} m (v_x^2 + v_y^2) = \frac{1}{2} m \left[\left(\frac{dq_1}{dt}\right)^2 + \left(\frac{dq_2}{dt}\right)^2 + 2\frac{dq_1}{dt}\frac{dq_2}{dt}\cos\alpha\right]$

$T = T_m + T_M \qquad = \frac{1}{2}(M+m)\left(\frac{dq_2}{dt}\right)^2 + \frac{1}{2} m \left[\left(\frac{dq_1}{dt}\right)^2 + 2\frac{dq_1}{dt}\frac{dq_2}{dt}\cos\alpha\right]$

$U = -m g q_1 \sin\alpha$

$$L = E_K - U = \frac{1}{2}(M+m)\left(\frac{dq}{dt}\right)^2 + \frac{1}{2} m \left[\left(\frac{dq_1}{dt}\right)^2 + 2\frac{dq_1}{dt}\frac{dq_2}{dt}\cos\alpha\right] + m g q_1 \sin\alpha$$

$\frac{\partial L}{\partial q_2} = \frac{d}{dt}\frac{\partial L}{\partial \dot{q}_2}$

$M\frac{dq_2}{dt} + m\left(\frac{dq_2}{dt} + \frac{dq_1}{dt}\cos\alpha\right) = \text{constant}$

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$\frac{\partial L}{\partial q_1} = \frac{d}{dt}\frac{\partial L}{\partial \dot{q}_1}$

$m g \sin\alpha = \frac{d}{dt}\left[m\left(\frac{dq_1}{dt} + \frac{dq_2}{dt}\cos\alpha\right)\right]$

$= m\left(\frac{d^2q_1}{dt^2} + \frac{d^2q_2}{dt^2}\cos\alpha\right)$