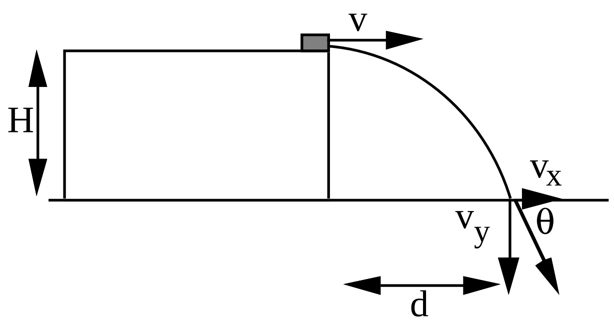
2000 test 1, PHYS 1989-1999

Question 1



Take the point of departure as the origin.

Nelgect air resistance, so there are no forces other than gravity acting on the canoe in flight, so

a) $y = y_o + v_{yo}t + \frac{1}{2}a_y t^2 = -\frac{1}{2}gt^2$

$-H = -\frac{1}{2}gt^2 \rightarrow t = \sqrt{2H/g} = 2.0\ s$

b) $x = x_o + v_{xo}t + \frac{1}{2}a_x t^2 = vt = 6.0\ m$

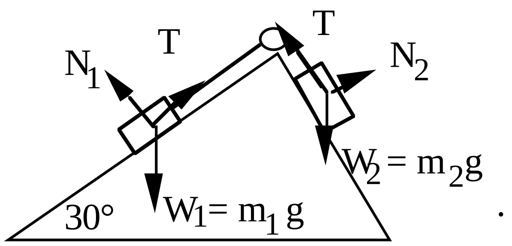
c) $v_x = v_{xo} + a_x t$

$= v$

$v_y = v_{yo} + a_y t = -gt$

$v_f = \sqrt{v_{xf}^2 + v_{yf}^2} = 20\ m.s^{-1}$

Question 2 (14 marks)

a) 

The pulley is massless, therefore it requires no torque to accelerate it, therefore the tensions in both parts of the string are the same.

b) Take the direction in which m_1 rises to be positive. Assume the string is inextensible, so acceleration a is same for both. Apply Newton's laws to obtain a

m_1, direction // plane: $T - m_1 g \sin 30° = m_1 a$ (1)

m_2, direction // plane: $m_2 g \sin 60° - T = m_2 a$ (2)

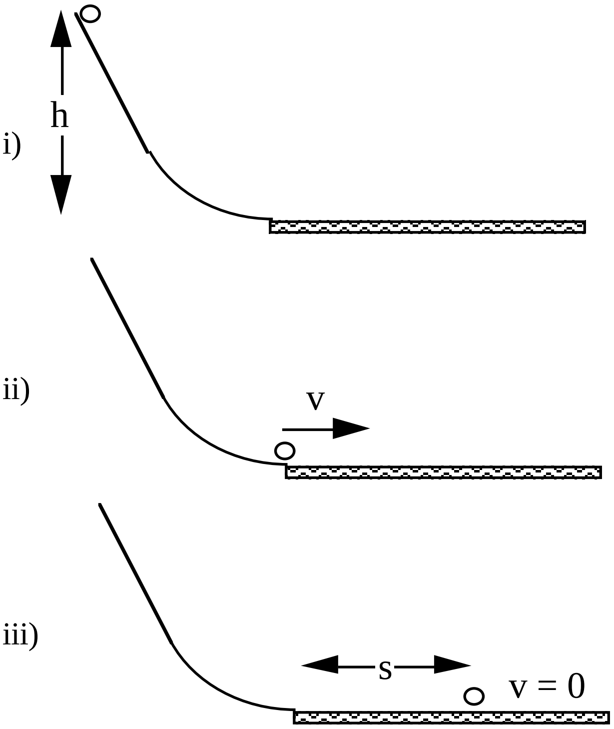
adding: $(m_1 + m_2)a = g(m_2 \sin 60° - m_1 \sin 30°)$

$$a = g\frac{m_2 \sin 60° - m_1 \sin 30°}{m_1 + m_2} = -1.1\ ms^{-2}$$

(ie m_1 accelerates down the plane and m_2 up the plane with acceleration $1.1\ ms^{-2}$.)

c) (1) $\rightarrow$ $T = m_1(g \sin 30° + a) = 19\ N$

Question 3 (18 marks)



Because the slope is smooth, no dissipative forces do work between (i) and (ii) ∴ mechanical energy is conserved, so

$$K_i + U_i = K_{ii} + U_{ii}$$

$$0 + mgh = \tfrac{1}{2}mv_{ii}^2 + 0 \qquad (1)$$

Between (ii) and (iii), only the frictional force F_f does work, so

$$W_f = \Delta K$$

F_f acts in opposite direction to motion and is constant so

$$-Fs = 0 - \tfrac{1}{2}mv_{ii}^2 \qquad (2)$$

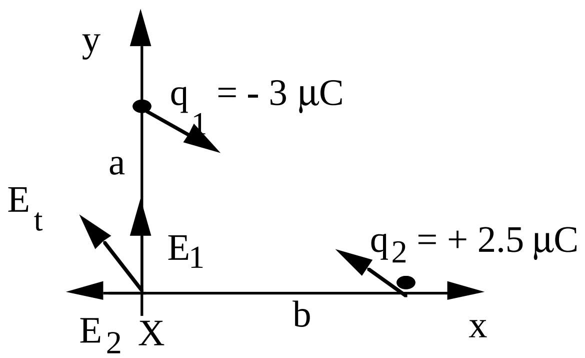
$Fs = \mu_k N = \mu_k mg$. Using (1) and (2)

$$-\mu_k mgs = -mgh$$

$$s = h/\mu_k$$

$$= 95\text{ m}$$

Question 4



a) r = separation = $\sqrt{a^2 + b^2}$

The magnitude of the force between the two charges is given by Coulomb's law:

$$F = \left|k\,\frac{q_1q_2}{r^2}\right|$$

$$= \left|k\,\frac{q_1q_2}{a^2+b^2}\right| = 2.7\text{ kN}$$

The forces are attractive and act on a line between them, as shown, ie the force on q_1 is $\tan^{-1}$ q/b = 37° below the positive x axis, while that on q_1 is 37° above the negative x axis.

b) $\underline{\mathbf{E}} = \underline{\mathbf{E}}_1 + \underline{\mathbf{E}}_2 = -k\frac{q_1}{a^2}\,\underline{\mathbf{y}} - k\frac{q_2}{b^2}\,\underline{\mathbf{x}} = (-1.4\,\underline{\mathbf{x}} + 3.0\,\underline{\mathbf{y}})\text{GV.m}^{-1} = (-1.4\,\underline{\mathbf{x}} + 3.0\,\underline{\mathbf{y}})\text{GN.C}^{-1}$

c) $V = V_1 + V_2 = k\frac{q_1}{a} + k\frac{q_2}{b} = -3.4\text{ MV}$

Question 5

Kirchoff's junction rule:

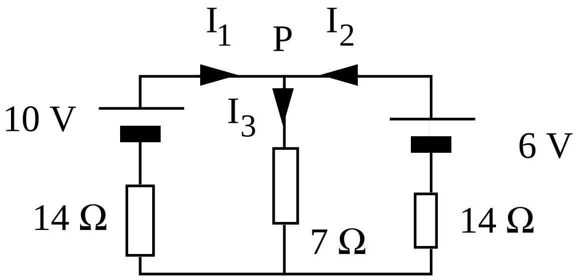
The sum of all currents flowing in to a point in a circuit equals zero. OR

The sum of currents flowing flowing in to a point in a circuit equals the sum of currents flowing out of that point in the circuit.

Kirchoff's loop rule:

The sum of changes in electrical potential difference around any loop in circuit is zero, OR

Around any loop in circuit, the sum of emfs equals the sum of drops in electrical potential difference.



Applying Kirchoff's junction rule at point P gives

$I_1 + I_2 - I_3 = 0$ (1)

b) Applying Kirchoff's loop rule to the loop on the left in the clockwise direction gives:

Σ emf $= \Sigma$ IR

$10 = 14I_1 + 7I_3$ (2) (in SI units)

Applying Kirchoff's loop rule to the loop on the right in the clockwise direction gives:

$-6 = -7I_3 - 14I_2$ (3)

Use (1) to eliminate I_1 from (2) gives

$10 = 14I_3 - 14I_2 + 7I_3$

Eliminating I_2 from (3) and the equation above gives

$10 + 6 = 21I_3 - 14I_2 + 7I_3 + 14I_2$

$I_3 = \frac{16}{28} = 0.6$ A

Therefore the potential difference across the 7 Ω resistor is 4 V.

Substituting for I_3 in (2) and (3) gives:

(2) $10 = 14I_1 + 7(4/7)$ $\therefore$ I = 6/14 A = 0.4 A

(3) $-6 = -7(4/7) - 14I_2$ $\therefore$ I = 2/14 A = 0.1 A