Q2. The 100-kg stone shown in Fig. Q2 is originally at rest on the smooth horizontal surface. If a towing force of 200 N, acting at an angle of 45°, is applied to the stone for 10 s, determine the final velocity and the normal force which the surface exerts on the stone during this time interval.

$m_s = 100\ kg,\ v_1 = 0,\ F = 200\ N,\ \theta = 45^\circ$

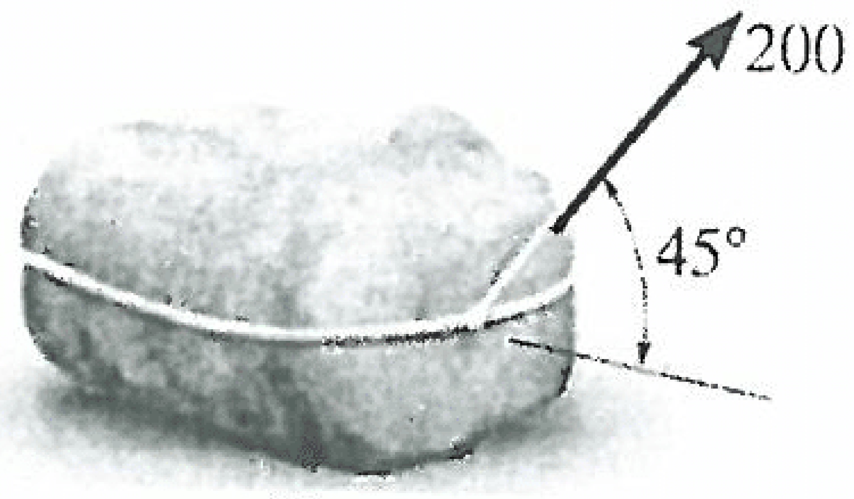
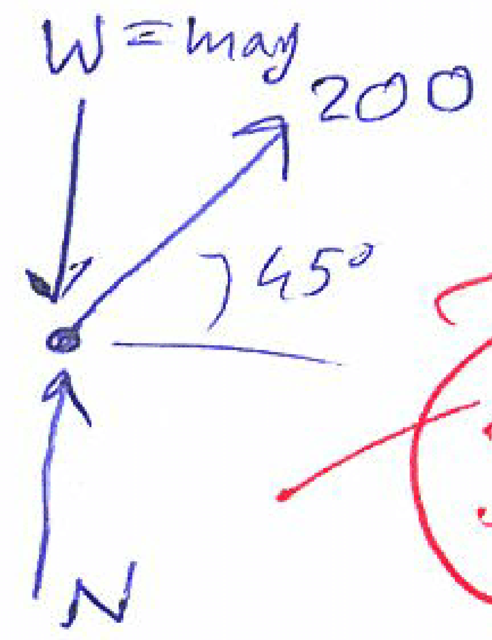


Figure – Q2

$s = 10\,s,\ V_2 = ?,\ N = ?$

$$mv_1 + \int_{t_1}^{t_2} F\,dt = mv_2$$



$$= 0 + \int_0^{10} 200\cos(45)\,dt = 100 \times V_2$$

10

5

$$V_2 = \frac{\left. 200\cos(45)t \right|_0^{10}}{100} = 14.14\ m/s$$

$\Sigma F_y = ma_y \Rightarrow \quad 200\sin(45) + N = 100 \times 9.81$

$N = 981 - 141.42 = 839.58\ (\uparrow)$ 10

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Q3. The 2-kg ball is thrown at the suspended 20-kg block with a velocity of 4 m/s. If the time of impact between the ball and the block is 0.005 s, determine the average normal force exerted on the block during this time. Take e = 0.8.

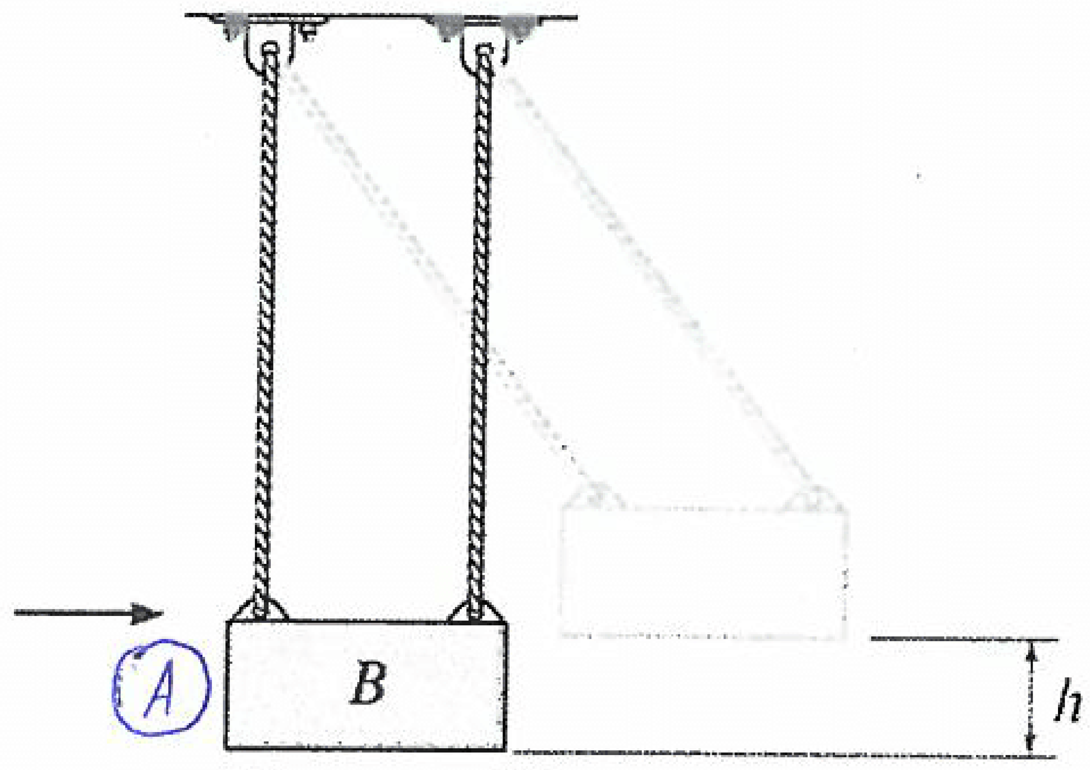

Figure – Q3

$m_A = 2\ kg$, $m_B = 20\ kg$, $V_{A_1} = 4\ m/s$

$t_I = 0.005 s$, $N_{avg} = ?$, $e = 0.8$

$V_{B(1)} = 0$, $V_{B_2} = ?$, $V_{A_2} = 0$

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$e = \frac{V_{B2} - V_{A2}}{V_{A1} - V_{B1}} \Rightarrow 0.8 = \frac{V_{B2} - 0}{4 - 0} \Rightarrow V_{B_2} = 4 \times 0.8 = 3.2\ m/s$

$\Sigma mV_1 = \Sigma mV_2 \Rightarrow 2(4) + 20(0) = 2(V_{A_2}) + 20(V_{B_2})$

$m_A V_{A_1} + m_B V_{B_1} = m_A V_{A_2} + m_B V_{B_2}$

$2(4) + 20(0) = 2(V_{A_2}) + 20(V_{B_2}) \Rightarrow 8 = 2V_{A_2} + 20V_{B2}$

$3.2 = V_{B2} - V_{A2}$ (8)

$V_{B2} = 3.2 + V_{A2}$

$20V_{B2} = 8 - 2V_{A2} \Rightarrow V_{B_2} = 0.4 - 0.1V_{A_2}$

$e = \frac{V_{B2} - V_{A2}}{V_{A1} - V_{B1}} = 0.8$

$0.8 = \frac{V_{B2} - 0}{4 - 0}$

$e = \frac{V_{B_2} - V_{A2}}{V_{A_1} - V_{B1}} = \frac{(0.4 - 0.1V_{A_2}) - V_{A_2}}{4 - 0} = 0.8$

$\Rightarrow \frac{-0.4V_{A_2} + 0.1V_{A_2}^2}{4} = 0.8 \Rightarrow 0.1V_{A_2}^2 - 0.4V_{A_2} = 3.2$

$2(4) + 0 = 2(V_{A_2}) + 20V$

$m_A V_{A_1} + m_B V_{B_1} = m_A V_{A_2} + m_B V_{B_2}$

$8 + 0 = 0 + 20V_{B_2} \Rightarrow V_{B_2} = \frac{8}{20} = 0.4$

$8 = 8 -$

$0.8 = \frac{0.4 - V_{A2}}{4 - 0} \Rightarrow 3.2 = 0.4 =$

$2(4) + 0 = 2V_{A2} + 20(3.2 + V_{A2})$

$8 = 2 + 64 + 20V_{A2}$

$V_{A2} = -2.9\ m/s$ (5)

$2(4) + F(0.005) = 2(0.3)$

Q1. The 10-kg block shown in Fig. Q1 rests on the smooth incline. If the spring is originally stretched 0.5 m, determine the total work done by all the forces acting on the block when a horizontal force P = 400 N pushes the block up the plane s = 2 m.

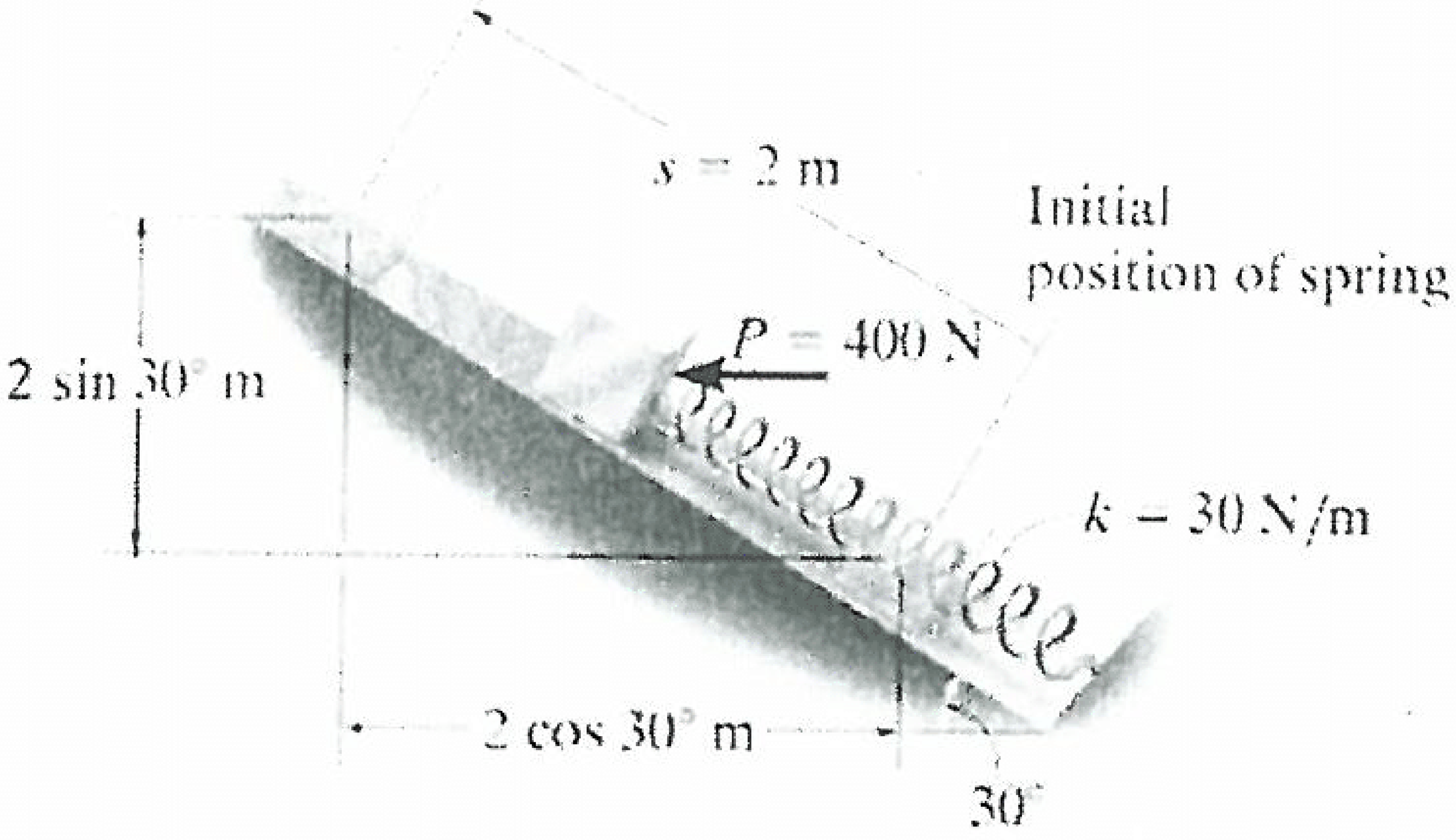
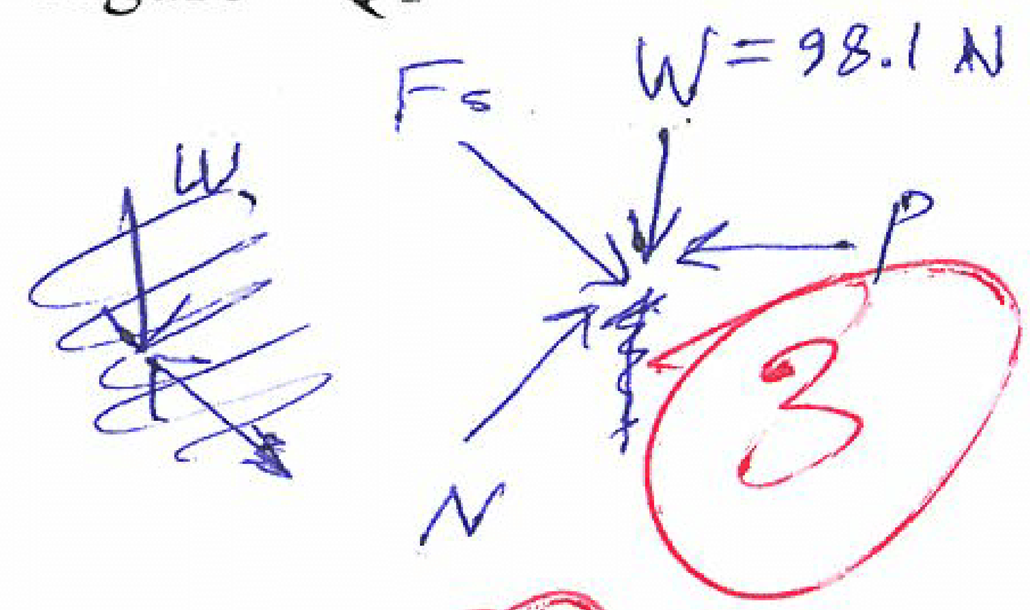


Figure – Q1



$(\overset{+}{\leftarrow})\ U_P = 400\ 2\cos 30 = 692.82\ J$ (5)

$(\overset{+}{\downarrow})\ U_W = -W\Delta y = 98.1 \times 2\sin 30 = -98.1\ J$ (6)

$(\searrow)\ U_s = F_s \times 2 = -\frac{k}{2}(s_2^2 - s_1^2) \times 2 = -30[(2+0.5)^2 - 0.5^2] = -180\ J$ (2)

$\Sigma U = 692.82 - 98.1 - 180\ J = 414.72\ J$ (3)

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