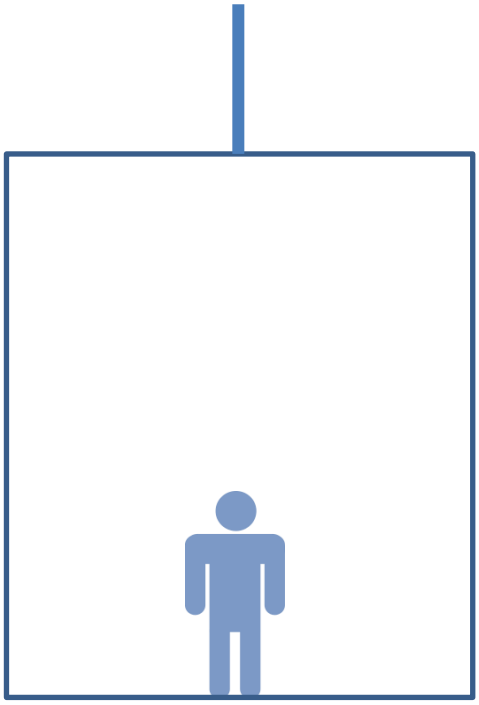
Forces, momentum and energy test Name:

1. An elevator with an initial velocity of 5 ms^{-1} comes to rest uniformly in 2 seconds. The elevator has a mass of 1000kg and the man inside has a mass of 100 kg.

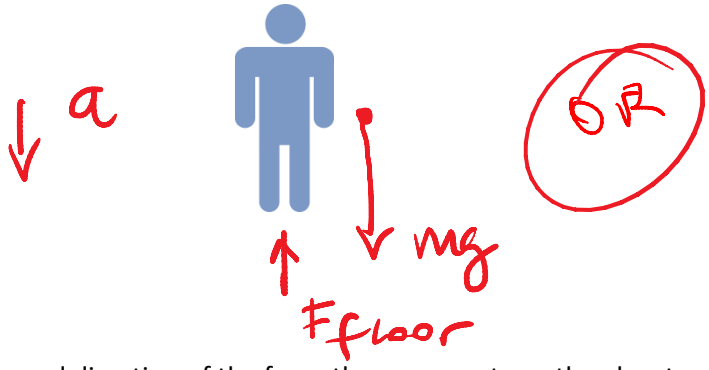


Note: "a" could be ↓ or ↑

(a) Determine the acceleration of the elevator (2 marks)

$a = -5/2\ ms^{-2}$

(b) Draw and label the forces acting on the man in the elevator. **Show the relative sizes of all force vectors (3 marks)**



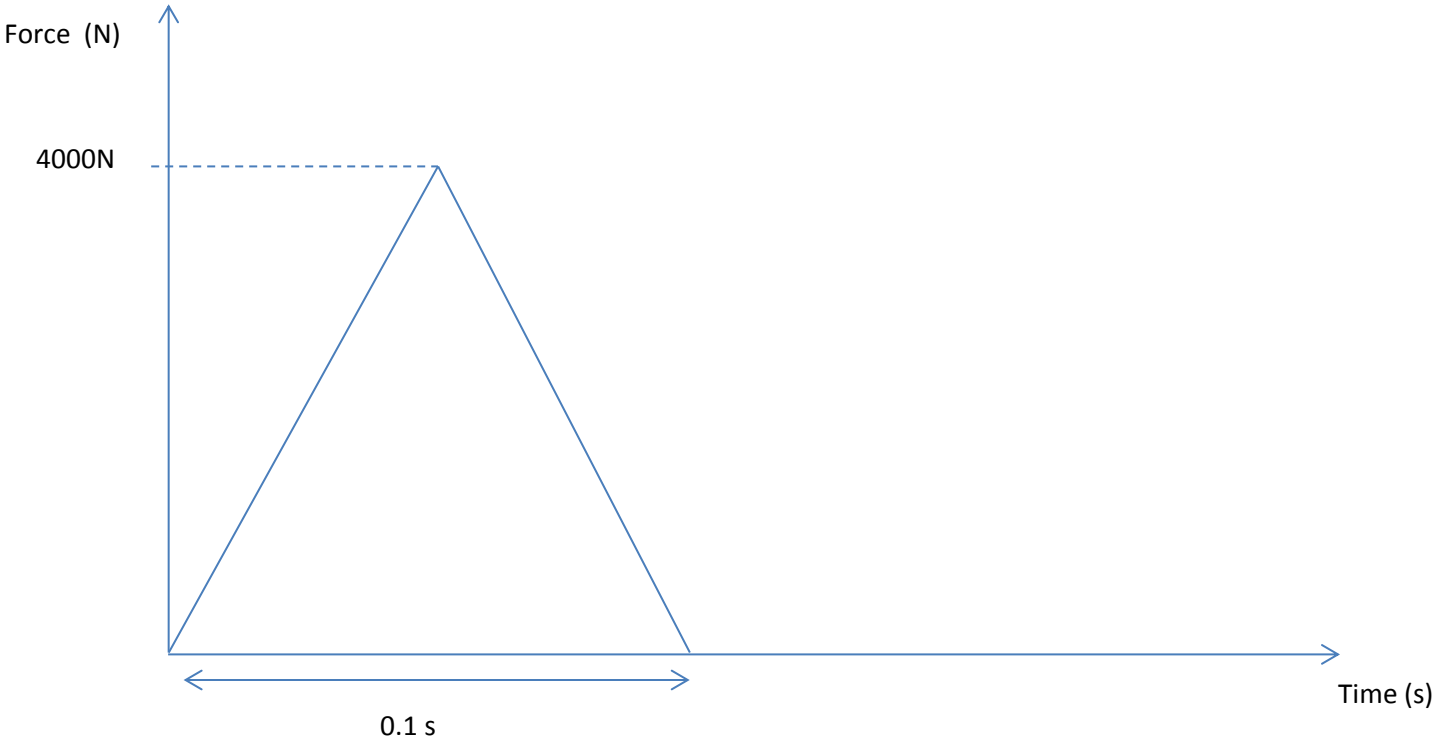
(c) State the magnitude and direction of the force the man exerts on the elevator. (3 marks)

$-mg + F_{floor} = m(-a)$

$F_{floor} = 100(10 - 2.5) = 750\ N$ OR $F_{floor} - mg = ma$

$F_f = 100(10 + 2.5) = 1250\ N$

2. A 50 kg girl is standing on a force plate. She jumps into the air in a vertical direction. The graph below shows the force from the plate acting on her feet.



(a) Determine the change in her momentum as a result of jumping off the plate. (2marks)

$\Delta p = \text{Area} = (2000)(0.1) = 200\ Ns$

(b) How high does she jump relative to the force plate (4 marks)

$50(v-0) = 200$

$v = 4\ ms^{-1}$

$v^2 = u^2 + 2as$

$0 = 16 + 2(-10)s$

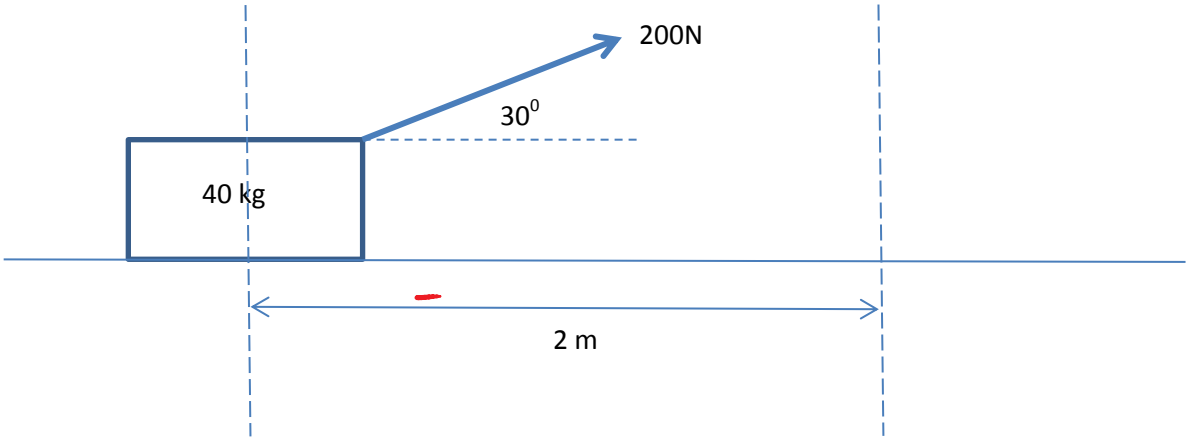
$s = 0.8\ m$

(c) What is her rate of change in momentum while she is in the air? (2 marks)

$\frac{\Delta p}{t} = -mg = -(50)(10)$

$= -500\ N$

3. A mass is being pulled across a frictionless table as shown below.



(a) What is the change in kinetic energy of the mass in moving across 2m? (2 marks)

$W = \Delta E_k = (200\cos 30^\circ)(2) = 346$ J

Consider now moving the same block with the same force across a surface of kinetic friction 0.2

(b) What force of friction acts on the mass (2 marks)

$F_f = \mu F_N = 0.2(40(10) - 200\sin 30^\circ)$
$= -60N$

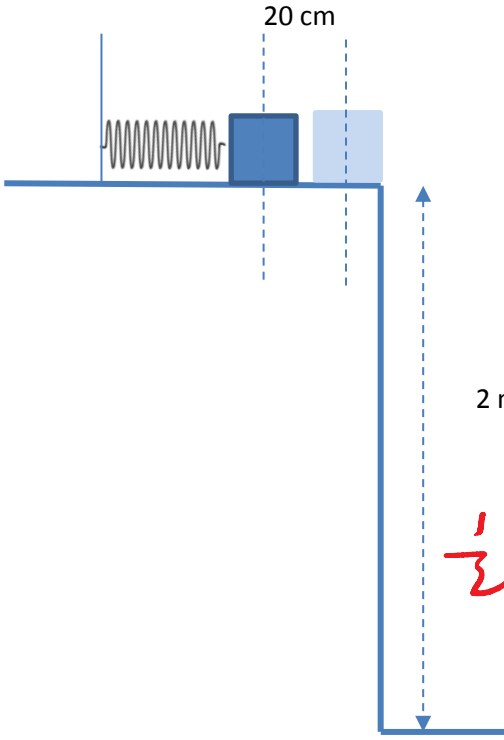
(c) What would be the change in kinetic energy if the surface had a coefficient of kinetic friction of 0.2 (3 marks)

$\Delta E_k = 346 - 60 \times 2$
$= 226$ J

(c) Explain why the change in kinetic energy calculated in (a) and (c) are different. (1mark)

E_k converted into heat through friction. (Mech Engy lost!)

4. A 50 gram mass is placed against a spring with a spring constant of 100Nm^{-1} as shown below. The spring + mass is displaced 20 cm
5. and released. The mass is allowed to project off a frictionless surface over a vertical height of 2 m.



$y_1 = 0$

$\frac{1}{2}kx^2 = mgy_2 + \frac{1}{2}mv^2$

$\frac{1}{2}(100)(0.2)^2 = (0.05)(10)(-2) + \frac{1}{2}(0.05)v^2$

$y_2 = 0$

(a) Determine the impact speed of the mass. (3 marks)

$v = 11 ms^{-1}$

(b) Explain how the horizontal displacement of the mass would change if the spring were displaced by 40 cm. (3 marks) $x = v_x \cdot t$ ∴ as x increases so does v_x ∴ x will double ✓✓

6. A car drives up a ramp inclined at 30^0 to the horizontal with a constant power of 100kW and speed of 20 ms^{-1}. The mass of the car is 500kg.

(a) What force of friction is opposing the motion of the car? (2 marks)

$F_{cw} = \frac{100\,000}{20} = 5000N$

$mg\sin\theta = 2500N$

$\therefore F_f = 2500N$

$f_f = 2500N$

(b) At what rate is mechanical energy being lost in this system (2 marks)

$P_{friction} = -2500 \times 20 = -50 kW$