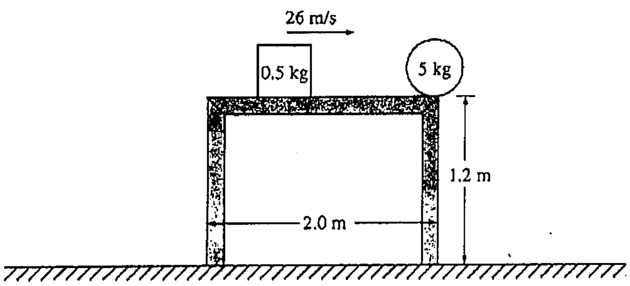
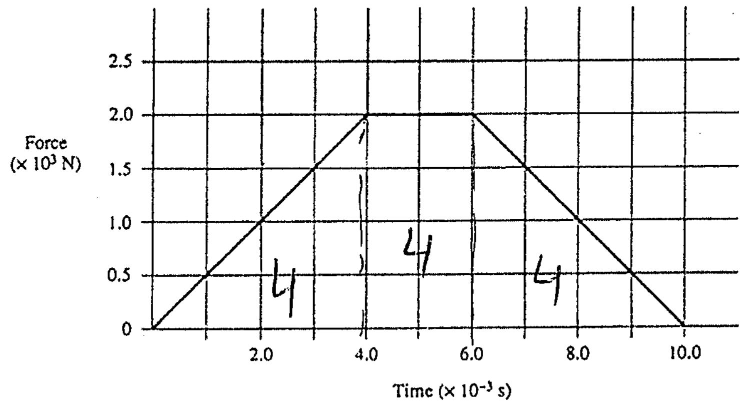


Note: Figure not drawn to scale.



12. A 5-kilogram ball initially rests at the edge of a 2-meter-long, 1.2-meter-high frictionless table, as shown above left. A hard plastic cube of mass 0.5 kilogram slides across the table at a speed of 26 meters per second and strikes the ball, causing the ball to leave the table in the direction in which the cube was moving. The figure above right shows a graph of the force exerted **on the ball** by the cube as a function of time.

a. Determine the total impulse given to the ball.

Area = 12 N·s

b. Determine the horizontal velocity of the ball immediately after the collision.

Impulse = Δp

$12 = m\Delta v$

$12 = 5(V_f - V_o)$

$12 = 5(V_f - 0)$

$V_f = 2.4 \text{ m/s}$

c. Determine the following for the cube immediately after the collision.

i. Its speed

.5 → 26 (5) | .5 $V_f = ?$ (5) → 2.4 m/s

$mv = mv + mv$

$.5(26) = .5V_f + 5(2.4)$

$13 = .5V_f - 12$

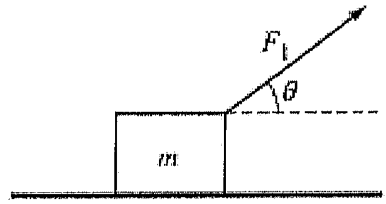
$1 = .5V_f$

$V_f = 2 \text{ m/s}$

ii. Its direction of travel (right or left), if moving

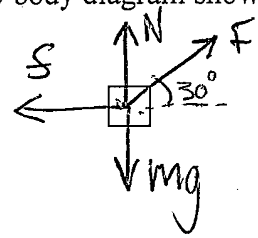
d. Is the impulse on the cube positive or negative, what is the value? How do you know?

Negative 12 N·s. Equal and opposite reaction force.



2. A block of mass m=10kg is pulled along a rough horizontal surface by a constant applied force of magnitude $F_1 = 50N$ that acts at an angle θ=30° to the horizontal, as indicated above. The coefficient of friction is 0.1.

a. On the figure below, draw and label a free-body diagram showing all the forces on the block.



x) $F\cos 30 - f = ma$

y) $N + F\sin 30 - mg = 0$

b. Find the normal force exerted by the surface on the block.

$N = mg - F\sin 30$

$N = 100 - 50\sin 30$

$N = 100 - 25 = \boxed{75N}$

c. Find the acceleration of the block.

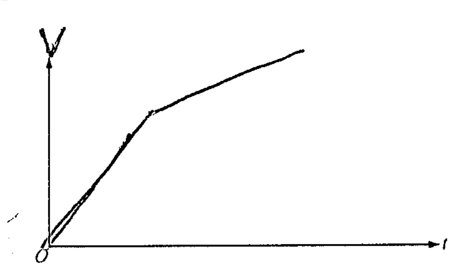
$F\cos 30 - \mu N = ma$

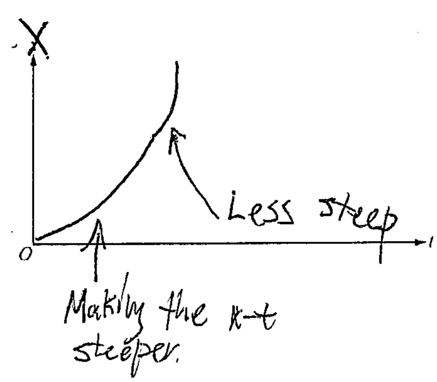
$50\cos 30 - 0.1(75) = 10a$

$\frac{43.3 - 7.5}{10} = a$

$\boxed{a = 3.58\ m/s^2}$

d. After a few seconds at that acceleration another mass was place on the block. On the axes below, sketch graphs of the speed v and displacement x of the block as functions of time t.





Question 1

10 points total | **Distribution of points**

(a) 4 points

For the correct value of t_1, the time car A is accelerating — 1 point

$v_f = v_i + at_1$

$t_1 = \left(v_f - v_i\right)/a = (5.0\ \text{m/s} - 2.0\ \text{m/s})/(1.5\ \text{m/s})$

$t_1 = 2.0\ \text{s}$

For a correct value of x_1, the distance car A travels while accelerating — 1 point

$x_1 = v_i t_1 + \frac{1}{2}at_1^2$

$x_1 = (2.0\ \text{m/s})(2.0\ \text{s}) + \frac{1}{2}\left(1.5\ \text{m/s}^2\right)(2.0\ \text{s})^2$

$x_1 = 7.0\ \text{m}$

Note: The equation $v_f^2 = v_i^2 + 2ax_1$ could also be used.

For a correct value of $(x - x_1)$, the distance car A travels at constant velocity — 1 point

$(x - x_1) = (15.0\ \text{m} - 7.0\ \text{m}) = 8.0\ \text{m}$

For correctly calculating t_2, the time car A travels at constant velocity — 1 point

$x = x_1 + v_f t_2$

$t_2 = (x - x_1)/v_f = (15.0\ \text{m} - 7.0\ \text{m})/5.0\ \text{m/s}$

$t_2 = 1.6\ \text{s}$

$t_{tot} = t_1 + t_2 = 2.0\ \text{s} + 1.6\ \text{s}$

$t_{tot} = 3.6\ \text{s}$

(b)

(i) 2 points

For any clear statement that momentum is conserved — 1 point

$m_A v_{Ai} = m_A v_{Af} + m_B v_B$

$$v_{Af} = \frac{m_A v_{Ai} - m_B v_B}{m_A} = \frac{(250\ \text{kg})(5.0\ \text{m/s}) - (200\ \text{kg})(4.8\ \text{m/s})}{250\ \text{kg}}$$

For a correct answer — 1 point

$v_{Af} = 1.2\ \text{m/s}$

(ii) 1 point

For indicating a direction of car A after the collision that is consistent with the calculation of v_{Af} — 1 point

Note: A correct calculation yields a direction to the right.

Question 1 (continued)

	Distribution of points
(c) 3 points	
For correctly indicating that the collision is <u>not</u> elastic	1 point
For a statement that kinetic energy is not conserved	1 point
For clearly showing that $K_f < K_i$, implying the collision is non-elastic	1 point

$$K_i = \frac{1}{2}m_A v_{Ai}^2 = \frac{1}{2}(250\text{ kg})(5.0\text{ m/s})^2$$

$$K_i = 3125\text{ J}$$

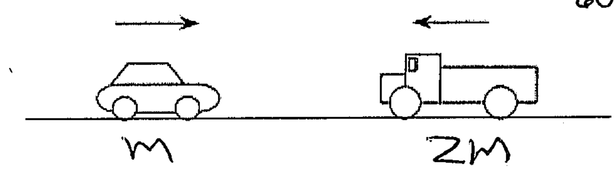
$$K_f = \frac{1}{2}m_A v_{Af}^2 + \frac{1}{2}m_B v_B = \frac{1}{2}(250\text{ kg})(1.2\text{ m/s})^2 + \frac{1}{2}(200\text{ kg})(4.8\text{ m/s})^2$$

$$K_f = 2484\text{ J}$$

Note: Two points were awarded for checking "yes" with a clear, correct explanation that it is a partially elastic collision.

5. A car and a truck are both travelling at the speed limit of 60 km h^{-1} but in opposite directions as shown. The truck has **twice** the mass of the car.

$60 \frac{km}{h} = 16.6 \, m/s$



The vehicles collide head-on and become entangled together.

(a) During the collision, how does the force exerted by the car on the truck compare with the force exerted by the truck on the car? Explain.

They are equal. When two objects interact the forces between them are equal.

(b) In what direction will the entangled vehicles move after collision or will they be stationary? Support your answer, referring to a physics principle.

They will move left. The total momentum is negative: $60m + -60(2m) = 3m(V)$

$-60m = 3mV$

$V = -20 \, km/h = 5.5 \, m/s$

(c) Determine the speed (in km h^{-1}) of the combined wreck immediately after the collision.

See above

(d) How does the acceleration of the car compare with the acceleration of the truck during the collision? Explain.

The acceleration of the small car is greater

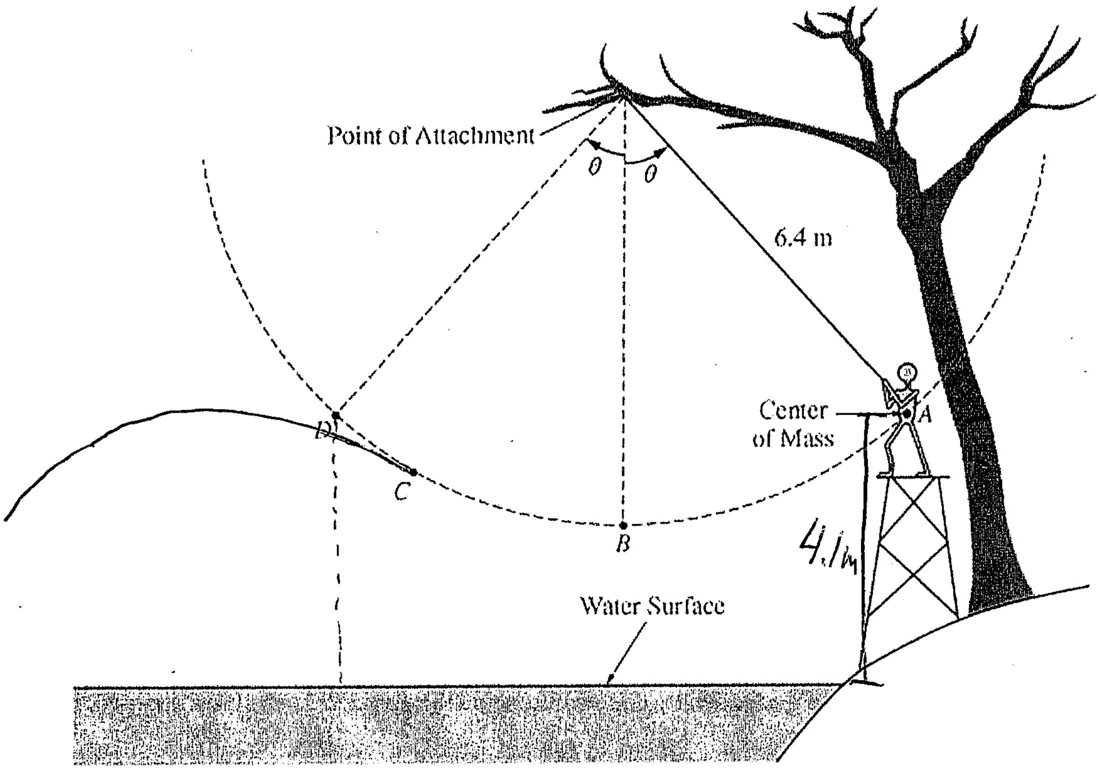
$a = \frac{F}{m}$ same F smaller m means greater a.

(e) Both the car and truck drivers are wearing seat belts. Which driver is likely to be the more severely jolted in the collision? Explain. *[2]*

The small car driver. They have a higher acceleration.

(f) The total kinetic energy of the system decreases as a result of the collision. Is the principle of conservation of energy violated? Explain. *[1]*

No, In an inelastic collision the KE is not conserved. Energy is dissipated in the collision.



1. (15 points)

Starting from rest at point A, a 50 kg person swings along a circular arc from a rope attached to a tree branch over a lake, as shown in the figure above. Point D is at the same height as point A. The distance from the point of attachment to the center of mass of the person is 6.4 m. Ignore air resistance and the mass and elasticity of the rope.

(a) The person swings two times, each time letting go of the rope at a different point.

i. On the first swing, the person lets go of the rope when first arriving at point C. Draw a solid line to represent the trajectory of the center of mass after the person releases the rope.

ii. A second time, the person lets go of the rope at point D. Draw a dashed line to represent the trajectory of the center of mass after the person releases the rope.

Since A is the same height as D there is no velocity at D.

(b) The center of mass of the person standing on the platform is at point A, 4.1 m above the surface of the water. Calculate the gravitational potential energy when the person is at point A relative to when the person is at the surface of the water.

(c) The center of mass of the person at point B, the lowest point along the arc, is 2.4 m above the surface of the water. Calculate the person's speed at point B.

(d) Suppose that the person swings from the rope a third time, letting go of the rope at point B. Calculate R, the horizontal distance moved from where the person releases the rope at point B to where the person hits the water.

(e) If the person does not let go of the rope, how does the magnitude of the person's momentum p_C at point C compare with the magnitude of the person's momentum p_B at point B?

___ $p_C > p_B$ X $p_C < p_B$ ___ $p_C = p_B$

Provide a physical explanation to justify your answer.

B) $mgh = 50(10)(4.1)$

$= 2050\text{J}$

c) $mgh_1 = \frac{1}{2}mv^2 + mgh_2$

$10(4.1) = \frac{1}{2}v^2 + 10(2.4)$

$41 = \frac{1}{2}v^2 + 24$

$34 = v^2$

$V = \sqrt{34}$

$V = 5.8\,\text{m/s}$

D) to find time use

$y = y_0 + V_0t + \frac{1}{2}at^2$

$2.4 = 0 + 0 + \frac{1}{2}(10)t^2$

$t = .69\,\text{s}$

to find distance

$x = x_0 + V_0t + \frac{1}{2}at^2$

$x = 0 + 5.8(.69) + \frac{1}{2}(0)t^2$

$x = 4\,\text{m}$

E) The momentum of c is less than the momentum of b. since impulse = Ft the force of gravity acts on the person over time and changed its momentum.

or use energy

At B the object is K at C it has K + U_s The velocity at C is less than B, so it has less momentum