PHYS 101 Midterm examination #1 (vers. 1D)

18 Oct., 2002 — Name: Key

Time: 50 minutes — Student No.

For questions 2 and 3, please show complete solutions and explain your reasoning, stating any principles that you have used.

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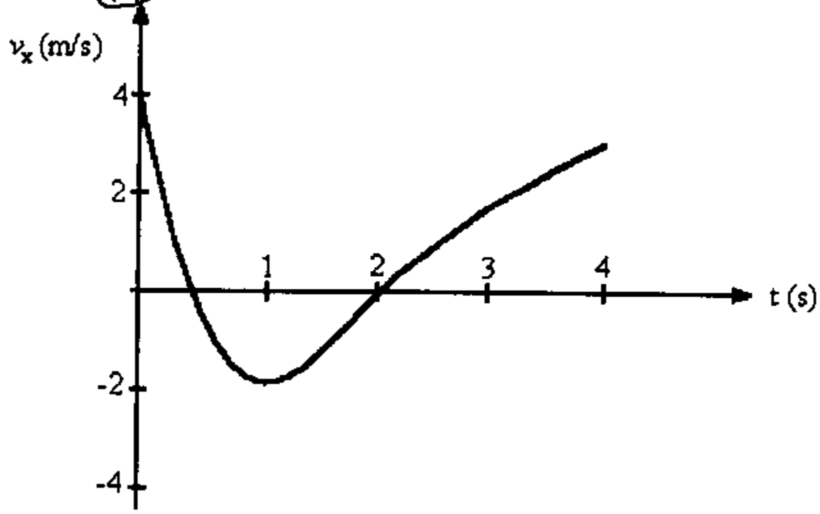
1 (10 marks). For each of the following five questions, please circle one answer only.

(e) (i) The figure below represents the velocity of a particle as it travels along the x axis. What is the average acceleration of the particle between t = 1 second and t = 4 seconds?

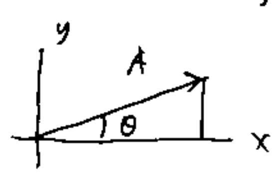
(a) 0.33 m/s^2
(b) 1.0 m/s^2
(c) 2.0 m/s^2
(d) 2.5 m/s^2
(e) 1.7 m/s^2

$$a_{ave} = \frac{\Delta v}{\Delta t} = \frac{3-(-2)}{4-1} = \frac{5}{3} = 1.7 \text{ m/s}^2$$



(a) (ii) A vector **A** has components A_x = 12 m and A_y = 5 m. What is the angle that vector **A** makes with the x axis?

(a) 22.6°
(b) 12.6°
(c) 32.6°
(d) 6.6°
(e) 13°



$$\theta = \tan^{-1}\frac{A_y}{A_x} = \tan^{-1}\frac{5}{12} = 22.6^\circ$$

(c) (iii) A boy kicks a football with an initial velocity of 20 m/s at an angle of 25° above the horizontal. Ignore the air resistance. The acceleration of the ball while it is in flight is

(a) 18 m/s^2
(b) 20 m/s^2
(c) 9.8 m/s^2
(d) 0
(e) 8.5 m/s^2

(e) (iv) A satellite is moving uniformly in a circular orbit around the earth. Which statement is NOT true?

(a) The gravitational force is perpendicular to the velocity of the satellite.
(b) The speed of the satellite is unchanged.
(c) The velocity of the satellite varies. $a_c = \frac{v^2}{R} \neq 0$
(d) The gravitational force equals the centripetal force.
(e) The acceleration is zero.

(b) (v) On a horizontal frictionless road, a car crashes into a minivan. Immediately after the collision, the two vehicles remain tangled together but free to coast. Consider the total momentum and the total kinetic energy of the two vehicles before and after the collision. {inelastic collis $K_i \neq K_f$.

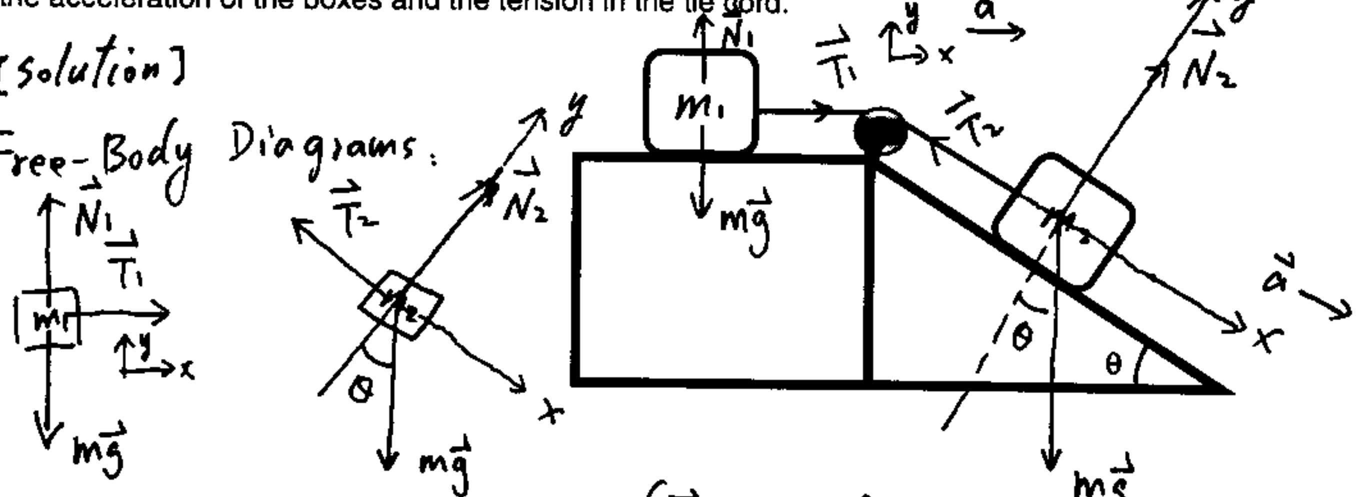
(a) Both the total momentum and total kinetic energy are conserved.
(b) The total momentum is conserved but the total kinetic energy is not conserved.
(c) Neither the total momentum nor the total kinetic energy is conserved.
(d) The total kinetic energy is conserved but the total momentum is not conserved.
(e) The change in total momentum equals the change in total kinetic energy.

$\left\{ \vec{F}_{net} = 0, \quad \vec{P}_i = \vec{P}_f \right.$

2(4 marks). As shown in the figure below, the two boxes have identical masses of 40 kg. The angle of inclination is θ=35°. Ignore the mass of the tie cord and all the frictional forces. Find the acceleration of the boxes and the tension in the tie cord.

[solution]

Free-Body Diagrams:



Newton's 2nd law of Motion: $(\vec{F}_{net} = m\vec{a})$

$m_1: \begin{cases} T_1 = ma & \cdots (1) \\ N_1 - mg = 0 & \cdots (2) \end{cases} \qquad m_2: \begin{cases} mg\sin\theta - T_2 = ma & \cdots (3) \\ N_2 - mg\cos\theta = 0 & \cdots (4) \end{cases}$

Note: $T_1 = T_2$, substitute (1) into (3):

A). $mg\sin\theta - ma = ma$, $a = \frac{1}{2}g\cdot\sin\theta$

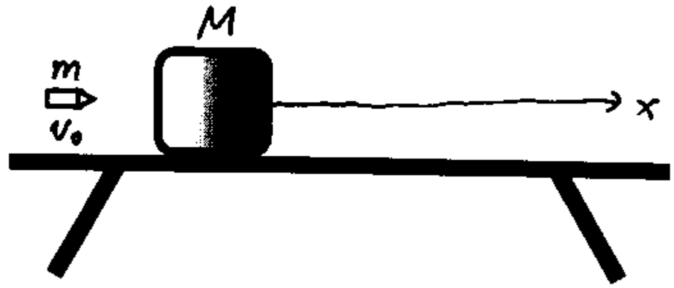
acceleration of blocks: $a = \frac{1}{2}(9.81)\sin 35° = 2.81\ m/s^2$

B): Tension: $T_1 = T_2 = ma = (40\ kg)(2.81\ m/s^2) = 113\ N$

3(6 marks). As shown in the figure below, a 0.012-kg bullet is fired horizontally into a 1.5-kg block. The bullet sticks in the block. The coefficient of kinetic friction between the block and the table is 0.25. Compute the speed of the bullet if the impact causes the block to move 0.60 m.

[solution].

The collision between the bullet and the block is completely inelastic.



Total momentum is conserved: $m v_0 = (m+M) V$.

Speed of (block + bullet) after collision: $V = \frac{m v_0}{m+M}$

After the collision, the friction acts on the block for a distance $d = 0.60\,m$ before the block stops.

$$W = \Delta K$$

$$-\mu_k \cdot N \cdot d = 0 - \frac{1}{2}(m+M)\cdot V^2$$

$$\mu_k (m+M) g \cdot d = \frac{1}{2}(m+M)\left(\frac{m v_0}{m+M}\right)^2$$

Solve for v_0: $2\mu_k (m+M)^2 g \cdot d = m^2 v_0^2$.

$$v_0 = \frac{m+M}{m}\sqrt{2\mu_k g \cdot d}.$$

$$= \frac{0.012 + 1.5}{0.012}\sqrt{2(0.25)(9.81)(0.60)}$$

$$= 215\ m/s$$