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

Feb 14, 2003 | Name________________________

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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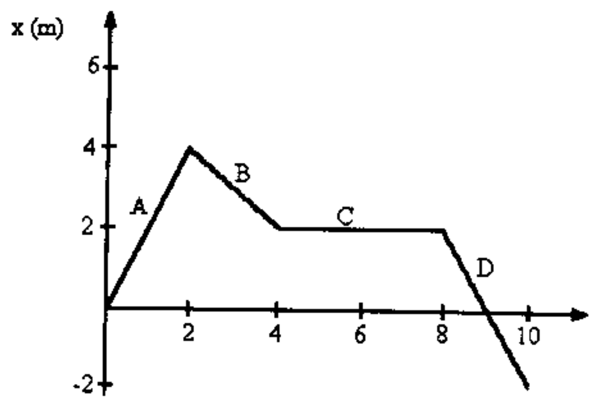
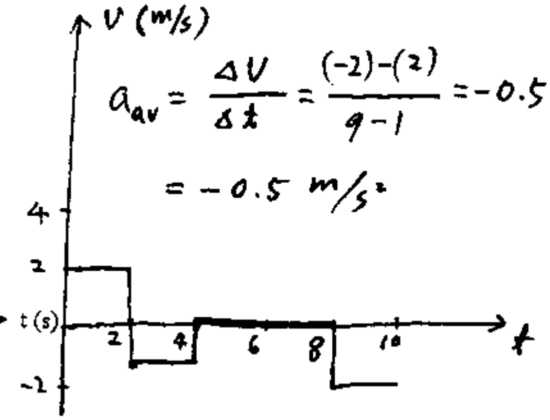
1 (10/20 marks). For each of the following five questions, please circle one answer only.

e

(i) The figure below represents the position of a particle as it travels along the x axis. What is the average acceleration of the particle in the time interval between t=1 s and t=9 s ?

(a) 18 m/s^2 (b) -0.25 m/s^2 (c) 0.25 m/s^2 (d) 0.50 m/s^2 (e) -0.50 m/s^2





$$a_{av} = \frac{\Delta v}{\Delta t} = \frac{(-2)-(2)}{9-1} = -0.5\ m/s^2$$

$$= -0.5\ m/s^2$$

b

(ii) A ball is thrown up into the air. Ignore air resistance. At the highest point in its trajectory, the net force acting on it

(a) is greater than its weight.
(b) is equal to its weight.
(c) is less than its weight, but not zero.
(d) is zero.
(e) depends on its height.

Anywhere during the projectile motion

c

(iii) What is the exponent n in the expression [power] $\propto$ [speed]^n for a drag force that varies with speed as $F_{drag} \propto v$?

(a) 4 (b) 3 (c) 2 (d) 1 (e) 0

$P = F \cdot v \propto v \cdot v \propto v^2$

d

(iv) A 900-kg car traveling east at 15 m/s collides with a 750-kg car traveling north at 20 m/s. The cars stick together. What is the speed of the wreckage just after the collision?

(a) 17.3 m/s (b) 25.0 m/s (c) 35.0 m/s (d) 12.2 m/s (e) 5.0 m/s

a

(v) An object at the end of a string is swung in a circular path at constant speed with a period T. If the period is halved without changing the radius of the circle, what is the new centripetal acceleration in terms of the original acceleration a ?

(a) 4a (b) 2a (c) a (d) a/2 (e) a/4

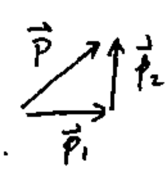
$a = \frac{v^2}{r}$, $v = \frac{2\pi r}{T}$.

$\therefore a = \frac{4\pi^2 r}{T^2}$.

$a_{new} = \frac{4\pi^2 r}{(T/2)^2} = 4 \cdot \frac{4\pi^2 r}{T} = 4a$.

(iv) $p_1 = 900 \times 15 = 13500\ kg \cdot m/s$

$p_2 = 750 \times 20 = 15000\ kg \cdot m/s$.



$P = \sqrt{p_1^2 + p_2^2} = 20180\ kg \cdot m/s$.

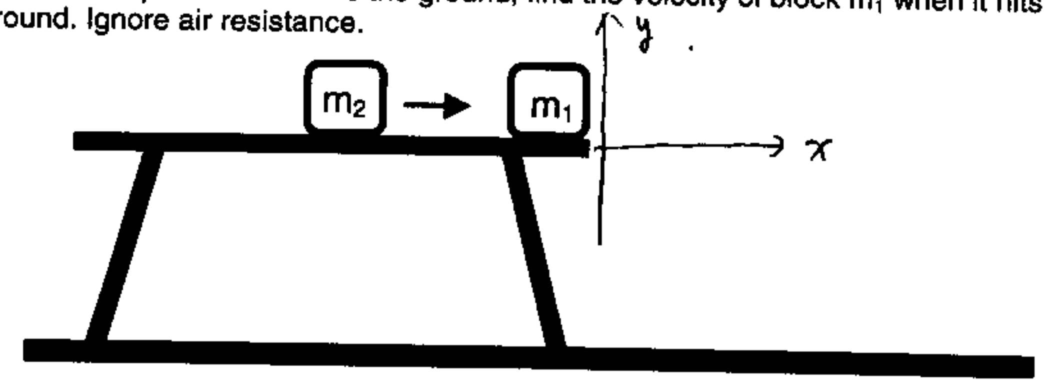
$v = \frac{P}{m_1 + m_2} = 12.2\ m/s$

2 (5/20 marks). A block of mass m_1=0.25 kg resting at the edge of a table is hit by a block of mass m_2=0.5 kg moving at a speed of 1.0 m/s, as shown in the figure below. Block m_2 stops immediately after the collision.

[2] A) Find the velocity of block m_1 immediately after the collision.

[1] B) During the collision, the two blocks interact with each other for a small time interval of 0.05 s, find the magnitude of the average force that m_2 exerts on m_1.

[2] C) If the tabletop is 1.0 m above the ground, find the velocity of block m_1 when it hits the ground. Ignore air resistance.



A). $\vec{F}_{ext} = 0$, Total momentum is conserved.

$m_2 V_2 = m_1 V_1'$, $\quad V_1' = \frac{m_2 V_2}{m_1} = \frac{(0.5)(1.0)}{(0.25)} = 2.0$ m/s

B). $F_2 \cdot \Delta t = \Delta P_2$

$F_2 = \frac{\Delta P_2}{\Delta t} = \frac{m_1 V_1'}{0.05} = \frac{(0.25)(2.0)}{0.05} = 10$ N

C). for m_1: $\begin{cases} a_x = 0 \\ a_y = -g \end{cases}$ $\quad \begin{cases} V_x = V_1' = 2.0 \text{ m/s} \\ V_y = -gt \end{cases}$ $\quad \begin{cases} x = V_1' \cdot t \\ y = -\frac{1}{2}gt^2 \end{cases}$

when m_1 hits the ground,

$y = -1.0$ m.

i.e. $-1 = -\frac{1}{2}gt^2$.

Solve for t: $\quad t = \sqrt{\frac{2}{g}}$.

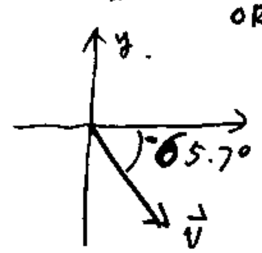
Then: $V_y = -g \cdot \sqrt{\frac{2}{g}} = -\sqrt{2g}$.

$= -4.43$ m/s

$\therefore V = \sqrt{V_x^2 + V_y^2} = 4.86$ m/s

$\theta = \tan^{-1}\frac{V_y}{V_x} = -65.7°$

OR: 294.3°

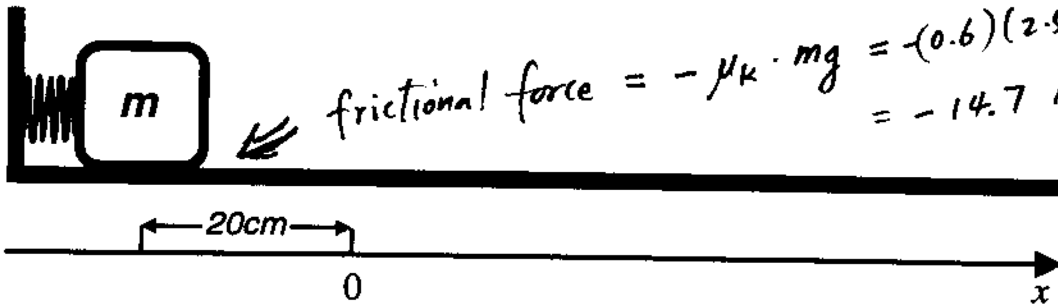


3 (5/20 marks). As shown in the figure below, a block of mass m=2.5 kg is pushed against a spring that has a force constant of 300 N/m, compressing it 20 cm (the block is not attached to the spring). The block is then released, and the spring pushes the block to move to the right. The coefficient of kinetic friction between the block and the ground is 0.60.

[2] A) Determine the distance the block will travel before it stops.

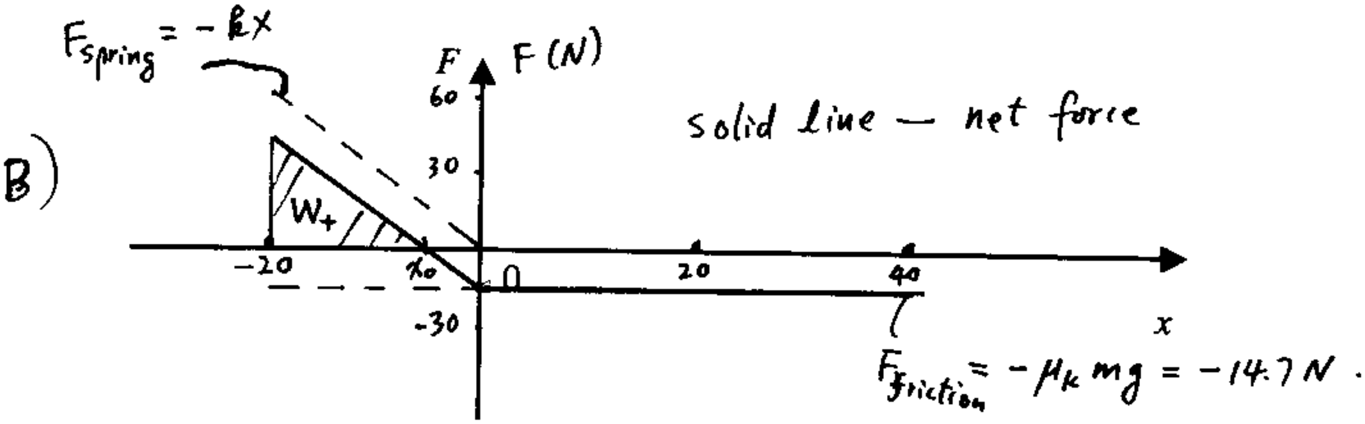
[1] B) Sketch the F ~ x curve, i.e., the net force acting on the block as a function of the block's position.

[2] C) Find the maximum speed of the block.



frictional force $= -\mu_K \cdot mg = -(0.6)(2.5)(9.8) = -14.7\ N$

B)



A). Generalized Work-Energy Theorm : $W_{nc} = \Delta E$.

i.e : $(\Delta x)\mu_K \cdot mg = \frac{1}{2} k x^2 \qquad (x = -0.2\,m)$

$$\Delta x = \frac{kx^2}{2\mu_K \cdot mg} = \frac{(300)(0.20)^2}{2(0.60)(2.5)(9.81)} = 0.408\ m \approx 41\ cm.$$

C). Maximum K.E: $\frac{1}{2} m V_{max}^2 = W_+$, i.e, $V_{max} = \sqrt{\frac{2W_+}{m}}$

to calculate W_+ : find x_0 first. ($F=0$ at x_0)

$$kx_0 = -\mu_k \cdot mg, \quad x_0 = \frac{-\mu_k mg}{k} = -0.049\ m.$$

$$W_+ = \frac{1}{2}(x_0 - x)(-kx - \mu_k mg) = \frac{1}{2}(0.20 - 0.049)(60 - 14.7) = 3.42\ J$$

$$V_{max} = \sqrt{\frac{2(3.42)}{2.5}} = 1.65\ m/s$$