111 學年第一學期 普通物理 B 第一次段考試題

[Wolfson Ch. 5-9] 2022/10/25, ***8:20am – 09:50am***

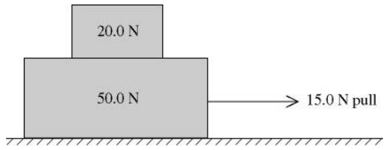
(i)依空格號碼順序在第二張**正面**寫下所有填充題答案，不要寫計算過程。

(ii)依計算題之題號順序在第二張**反面**以後寫下演算過程與答案，**每題從新的一頁寫起**。

Useful constant: The gravitational field on Earth g = 9.803 m/s^2, Graviational constant G = 6.6741*10^{-11} N m^2/kg^2, The Earth's radius Re = 6378077 m, The earth's mass Me = 5.9763*10^{24} kg.

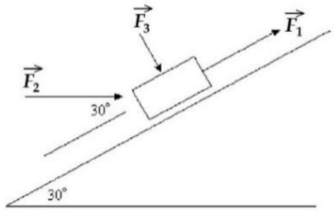
Part I. Filling the blank (75 points)

• A 20.0-N box rests on a 50.0-N box on a perfectly smooth horizontal floor. When a horizontal 15.0-N pull to the right is exerted on the lower box (see the right figure), both boxes move together. Find the magnitude 【01a】 (3 points) and direction 【01b】 (2 points) of the net external force on the upper box.

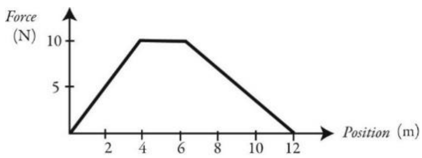


• A block is given a very brief push up a 20.0° frictionless incline to give it an initial speed of 12.0 m/s. How far along the surface of the plane does the block slide before coming to rest? 【02a】 (2.5 points) How much time does it take to return to its starting position? 【02b】 (2.5 points)

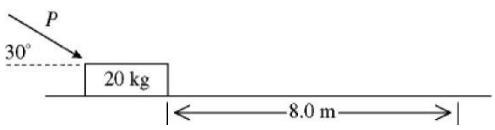
• Three forces, F_1 = 20.0 N, F_2 = 40.0 N, and F_3 = 10.0 N act on an object with a mass of 2.00 kg which can move along a frictionless inclined plane as shown in the right figure. When the object has moved through a distance of 0.600 m along the surface of the inclined plane in the upward direction. What is the amount of work done by F_1? 【03a】 (2 points) F_2? 【03b】 (2 points) F_3? 【03c】 (1 point)



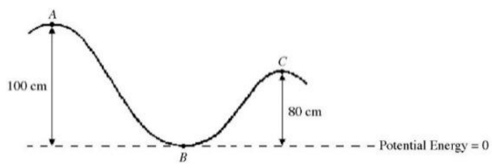
• An object is acted upon by a force that represented by the force vs. position graph in the right figure. What is the work done as the object moves from 4 m to 6 m? 【04a】 (2 points) from 6 m to 12 m? 【04b】 (3 points)



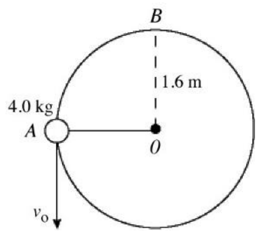
• In the right figure, a constant external force *P* = 160 N is applied to a 20.0-kg box, which is on a rough horizontal surface. While the force pushes the box a distance of 8.00 m, the speed changes from 0.500 m/s to 2.60 m/s. The work done by friction during this process is 【05】 (5 points).



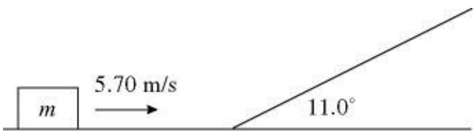
• A 2.0 g bead slides along a frictionless wire, as shown in the right figure. At point *A*, the bead is moving to the right but with negligible speed. What is the potential energy of the bead at point *A*? 【6a】 (2 points) What is the speed of the bead at point *B*? 【6b】 (2 points) What is the speed of the bead at point *C*? 【6c】 (1 point)



• In the right figure, a 4.0-kg ball is on the end of a 1.6-m rope that is fixed at *0*. The ball is held at point *A*, with the rope horizontal, and is given an initial downward velocity. The ball moves through three quarters of a circle with no friction and arrives at *B*, with the rope barely under tension. The initial velocity of the ball, at point *A*, is 【07】 (5 points)

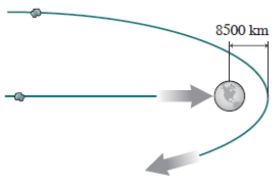


• In the right figure, a block of mass *m* is moving along the horizontal frictionless surface with a speed of 5.70 m/s. If the slope is 11.0° and the coefficient of kinetic friction between the block and the incline is 0.260, how far does the block travel up the incline? 【08】 (5 points)



• Given that our Sun orbits the galaxy with a period of 2.0×10^8y at 2.6×10^{20}m from the galactic center, the estimated mass of the galaxy's is 【09】(5 points) kg. Assume (incorrectly) that the galaxy is essentially spherical and that most of its mass lies interior to the Sun's orbit.

• Two meteoroids are 250,000 km from Earth's center and moving at 2.1 km/s. One is headed straight for Earth, while the other is on a path that will come within 8500 km of Earth's center (as shown in the figure). The speed of the first meteoroid when it strikes Earth is 【10a】(2.5 points) and speed of the second meteoroid at its closest approach is 【10b】(2.5 points).



• An astronaut is in equilibrium when he is positioned $140km$ from the center of asteroid X and $581\ km$ from the center of asteroid Y, along the straight line joining the centers of the asteroids. The ratio of the masses of the asteroids M_X/M_Y is 【11】(5 points).

• The linear density of a rod, in g/m, is given by $\lambda(x) = 40.0 + 30.0x$. The rod extends from the origin to x = 0.400 m. The center of mass of the rod is $x =$【12】(5 points) m.

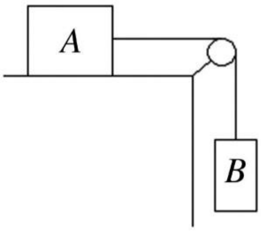
• A fireworks rocket is launched vertically upward at 40 m/s. At the peak of its trajectory, it explodes into two equal-mass fragments. One reaches the ground 2.87 s after the explosion. When does the second reach the ground? 【13】(5 points) s

• A neutron (mass 1.01 u) strikes a deuteron (mass 2.01 u), and they combine to form a tritium nucleus (mass 3.02 u). If the neutron's initial velocity was $23.5\hat{\imath} + 14.4\hat{\jmath}$ Mm/s and if the tritium leaves the reaction with velocity $15.1\hat{\imath} + 22.6\hat{\jmath}$ Mm/s, the deuteron's velocity is 【14】(5 points).

• At an instant when a particle of mass 80 g has a velocity of 25 m/s in the positive y direction, a 75-g particle has a velocity of 20 m/s in the positive x direction. The speed of the center of mass of this two-particle system at this instant is 【15】(5 points).

Part II Problems (10 points per problem)

【1】 Two boxes are connected by a weightless cord running over a very light frictionless pulley as shown in the right figure. Box *A*, of mass 8.0 kg, is initially at rest on the top of the table. The coefficient of kinetic friction between box *A* and the table is 0.10. Box *B* has a mass of 15.0 kg, and the system begins to move just after it is released.

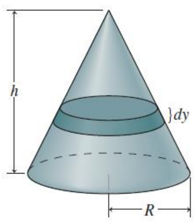


(a) Draw the free-body diagrams for each of the boxes, identifying all of the forces acting on each one.

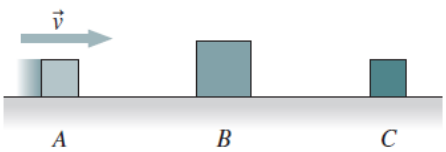
(b) Calculate the acceleration of each box.

(c) What is the tension in the cord?

【2】Find the center of mass of the uniform, solid cone of height h, base radius R, and constant density ρ shown in the right figure.



【3】Blocks A, B and C have masses $m, 2m,$ and m, respectively, and are at rest on a frictionless surface. Block A is heading at speed v toward block B as shown in the right figure. Determine the final velocity of each block after all subsequent collisions are over. Assume all collisions are elastic.



Part I Answer Sheet, **Note: 有效位數錯誤者，扣 0.5 分。**

A【01a】	4.29 N (3 points)	A【01b】	to the right (2 points)		
A【02a】	21.5 m (2.5 points)	A【02b】	7.16 s (2.5 points)		
A【03a】	12.0 J (2 points)	A【03b】	20.8 J (2 points)	A【03c】	0.00 J (1 point)
A【04a】	20 J (2 points)	A【04b】	30 J (3 points)		
A【05】	-1040 J (5 points)				
A【6a】	2.0×10^{-2} J (2 points)	A【6b】	4.4 m/s (2 points)	A【6c】	2.0 m/s (1 point)
A【07】	6.9 m/s (5 points)				
A【08】	3.72 m (5 points)				
A【09】	2.6×10^{41} (5 points)				
A【10a】	11.4 km / s (2.5 points)	A【10b】	9.67 km / s (2.5 points)		
A【11】	0.0581 (5 points)				
A【12】	0.213 (5 points)				
A【13】	6.04 (5 points)				
A【14】	$10.9\hat{\imath} + 26.7\hat{\jmath}$ Mm/s (5 points)				
A【15】	16 m/s (5 points)				

Part II Answer Sheet，**Note:** 有效位數錯誤者，扣 **0.5** 分。

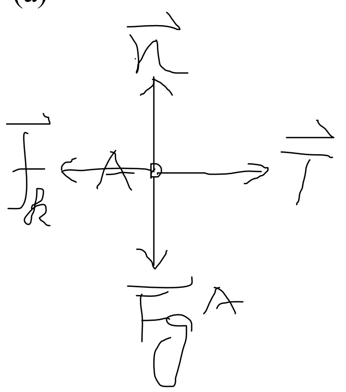
A1

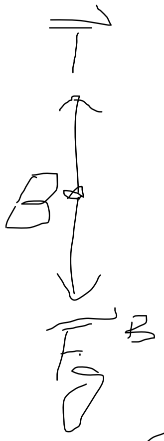
(a) see below

(b) 6.1 m/s^2

(c) 56 N

(a)





$\vec{F}_g^B - T = m_B a$

$T = m_B(g-a)$

$T - f_k = m_A a$, $T = m_A a + n\mu_k =$

(b) $6.1\ m/s^2$

$\Rightarrow m_B(g-a) = m_A(a + g\mu_k)$

$$\Rightarrow a = \frac{m_B g - m_A g \mu_k}{m_A + m_B} = \frac{139.16}{23} = 6.05\ m/s^2$$

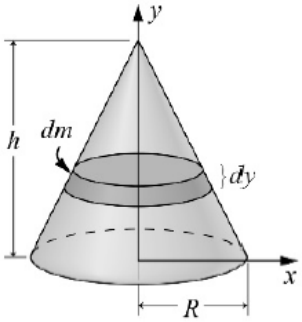
$\Rightarrow T = 15(9.8 - 6.05) = 56.24\ N$

$= 56\ N$ (c)

A2

$$z_{\text{cm}} = \frac{\int z\,dm}{M}$$

For the mass element dm, take a disk at height z and of radius $r = R(1 - z/h)$ that is parallel to th $dm = \rho\pi r^2 dz = \rho\pi R^2 (1 - z/h)^2 dz$ where ρ is the density of the cone, and $M = \frac{1}{3}\rho\pi R^2 h$ is the cone.



EVALUATE For the z-coordinate of the center of mass, the integral above gives

$$z_{\text{cm}} = \frac{1}{M}\int_0^h z\,dm = \frac{3}{\rho\pi R^2 h}\int_0^h z\rho\pi R^2 (1 - z/h)^2 dz$$

$$= \frac{3}{h}\int_0^h \left(z - \frac{2z^2}{h} + \frac{z^3}{h^2} \right) dz = \frac{3}{h}\left(\frac{h^2}{2} - \frac{2h^2}{3} + \frac{h^2}{4} \right) = \frac{1}{4}h$$

A3

DEVELOP We can analyze separately the two collisions in this problem, and apply Equations 9.15 to each collision. For the first collision, between blocks A and B, we find (with $v_{\text{af}} \equiv v$)

$$v_{\text{Af}} = \frac{m_A - m_B}{m_A + m_B} v_{\text{Ai}} + \frac{2m_B}{m_A + m_B} \overbrace{v_{\text{Bi}}}^{=0} = \frac{m_A - m_B}{m_A + m_B} v_{\text{Ai}}$$

$$v_{\text{Bf,int}} = \frac{m_B - m_A}{m_A + m_B} \overbrace{v_{\text{Bi}}}^{=0} + \frac{2m_A}{m_A + m_B} v_{\text{Ai}} = \frac{2m_A}{m_A + m_B} v_{\text{Ai}}$$

where $v_{\text{Bf,int}}$ is the intermediate final velocity of block B. Block B then proceeds to collide with block C, and the final velocities from that collision are

$$v_{\text{Bf}} = \frac{m_B - m_C}{m_B + m_C} v_{\text{Bf,int}} + \frac{2m_C}{m_B + m_C} \overbrace{v_{\text{Ci}}}^{=0} = \frac{m_B - m_C}{m_B + m_C} v_{\text{Bf,int}}$$

$$v_{\text{Cf}} = \frac{m_C - m_B}{m_C + m_B} \overbrace{v_{\text{Ci}}}^{=0} + \frac{2m_B}{m_A + m_B} v_{\text{Bf,int}} = \frac{2m_B}{m_A + m_B} v_{\text{Bf,int}}$$

EVALUATE Inserting the masses of the blocks $m_A = m$, $m_B = 2m$, and $m_C = m$, and recalling that $v_{\text{Af}} \equiv v$, we find

$$v_{\text{Af}} = \frac{m - 2m}{m + 2m} v_{\text{Ai}} = -\frac{1}{3} v$$

$$v_{\text{Bf,int}} = \frac{2m}{m + 2m} v_{\text{Ai}} = \frac{2}{3} v$$

$$v_{\text{Bf}} = \frac{2m - m}{2m + m} v_{\text{Bf,int}} = \left(\frac{1}{3}\right)\left(\frac{2}{3}\right) v_{\text{Ai}} = \frac{2}{9} v$$

$$v_{\text{Cf}} = \frac{2m_B}{m_A + m_B} v_{\text{Bf,int}} = \frac{4m}{m + 2m}\left(\frac{2}{3}\right) v_{\text{Ai}} = \frac{8}{9} v$$