Name:_____

Answer Sheet for AP Physics C: Mechanics

Practice Exam, Section I

No.	Answer
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	

No.	Answer
19	
20	
21	
22	
23	
24	
25	
26	
27	
28	
29	
30	
31	
32	
33	
34	
35	

老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）

AP® Physics C: Mechanics Exam

SECTION I: Multiple Choice

2019

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

At a Glance

Total Time
45 minutes
Number of Questions
35
Percent of Total Score
50%
Writing Instrument
Pencil required
Electronic Device
Calculator allowed

Instructions

Section I of this exam contains 35 multiple-choice questions. For these questions, fill in only the circles for numbers 1 through 35 on your answer sheet. A table of information and lists of equations that may be helpful are in the booklet. Calculators, rulers and straightedges may be used in this section.

Indicate all of your answers to the multiple-choice questions on the answer sheet. No credit will be given for anything written in this exam booklet, but you may use the booklet for notes or scratch work. After you have decided which of the suggested answers is best, completely fill in the corresponding circle on the answer sheet. Give only one answer to each question. If you change an answer, be sure that the previous mark is erased completely. Here is a sample question and answer.

Sample Question	Sample Answer
Chicago is a (A) state (B) city (C) country (D) continent (E) village	Ⓐ ● Ⓒ Ⓓ Ⓔ

Use your time effectively, working as quickly as you can without losing accuracy. Do not spend too much time on any one question. Go on to other questions and come back to the ones you have not answered if you have time. It is not expected that everyone will know the answers to all of the multiple-choice questions.

Your total score on the multiple-choice section is based only on the number of questions answered correctly. Points are not deducted for incorrect answers or unanswered questions.

Form I
Form Code 4PBP4-S

老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）

ADVANCED PLACEMENT PHYSICS C TABLE OF INFORMATION

CONSTANTS AND CONVERSION FACTORS

Proton mass,	$m_p = 1.67 \times 10^{-27}$ kg	Electron charge magnitude,	$e = 1.60 \times 10^{-19}$ C
Neutron mass,	$m_n = 1.67 \times 10^{-27}$ kg	1 electron volt,	1 eV $= 1.60 \times 10^{-19}$ J
Electron mass,	$m_e = 9.11 \times 10^{-31}$ kg	Speed of light,	$c = 3.00 \times 10^{8}$ m/s
Avogadro's number,	$N_0 = 6.02 \times 10^{23}$ mol^{-1}	Universal gravitational constant,	$G = 6.67 \times 10^{-11}$ $\left(\text{N}\cdot\text{m}^2\right)/\text{kg}^2$
Universal gas constant,	$R = 8.31$ J/(mol·K)	Acceleration due to gravity at Earth's surface,	$g = 9.8$ m/s^2
Boltzmann's constant,	$k_B = 1.38 \times 10^{-23}$ J/K		

1 unified atomic mass unit,	1 u $= 1.66 \times 10^{-27}$ kg $= 931$ MeV/c^2
Planck's constant,	$h = 6.63 \times 10^{-34}$ J·s $= 4.14 \times 10^{-15}$ eV·s
	$hc = 1.99 \times 10^{-25}$ J·m $= 1.24 \times 10^{3}$ eV·nm
Vacuum permittivity,	$\varepsilon_0 = 8.85 \times 10^{-12}$ C$^2/\left(\text{N}\cdot\text{m}^2\right)$
Coulomb's law constant,	$k = 1/(4\pi\varepsilon_0) = 9.0 \times 10^{9}$ $\left(\text{N}\cdot\text{m}^2\right)/\text{C}^2$
Vacuum permeability,	$\mu_0 = 4\pi \times 10^{-7}$ (T·m)/A
Magnetic constant,	$k' = \mu_0/(4\pi) = 1 \times 10^{-7}$ (T·m)/A
1 atmosphere pressure,	1 atm $= 1.0 \times 10^{5}$ N/m^2 $= 1.0 \times 10^{5}$ Pa

UNIT SYMBOLS	meter,	m	mole,	mol	watt,	W	farad,	F
	kilogram,	kg	hertz,	Hz	coulomb,	C	tesla,	T
	second,	s	newton,	N	volt,	V	degree Celsius,	°C
	ampere,	A	pascal,	Pa	ohm,	Ω	electron volt,	eV
	kelvin,	K	joule,	J	henry,	H		

PREFIXES		
Factor	Prefix	Symbol
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p

VALUES OF TRIGONOMETRIC FUNCTIONS FOR COMMON ANGLES							
θ	0°	30°	37°	45°	53°	60°	90°
$\sin\theta$	0	1/2	3/5	$\sqrt{2}/2$	4/5	$\sqrt{3}/2$	1
$\cos\theta$	1	$\sqrt{3}/2$	4/5	$\sqrt{2}/2$	3/5	1/2	0
$\tan\theta$	0	$\sqrt{3}/3$	3/4	1	4/3	$\sqrt{3}$	∞

The following assumptions are used in this exam.

I. The frame of reference of any problem is inertial unless otherwise stated.
II. The direction of current is the direction in which positive charges would drift.
III. The electric potential is zero at an infinite distance from an isolated point charge.
IV. All batteries and meters are ideal unless otherwise stated.
V. Edge effects for the electric field of a parallel plate capacitor are negligible unless otherwise stated.

老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）

ADVANCED PLACEMENT PHYSICS C EQUATIONS

MECHANICS

$v_x = v_{x0} + a_x t$

$x = x_0 + v_{x0} t + \frac{1}{2} a_x t^2$

$v_x^2 = {v_{x0}}^2 + 2a_x (x - x_0)$

$\vec{a} = \frac{\sum \vec{F}}{m} = \frac{\vec{F}_{net}}{m}$

$\vec{F} = \frac{d\vec{p}}{dt}$

$\vec{J} = \int \vec{F}\, dt = \Delta\vec{p}$

$\vec{p} = m\vec{v}$

$\left|\vec{F}_f\right| \le \mu \left|\vec{F}_N\right|$

$\Delta E = W = \int \vec{F} \bullet d\vec{r}$

$K = \frac{1}{2} m v^2$

$P = \frac{dE}{dt}$

$P = \vec{F} \bullet \vec{v}$

$\Delta U_g = mg\Delta h$

$a_c = \frac{v^2}{r} = \omega^2 r$

$\vec{\tau} = \vec{r} \times \vec{F}$

$\vec{\alpha} = \frac{\sum \vec{\tau}}{I} = \frac{\vec{\tau}_{net}}{I}$

$I = \int r^2 dm = \sum m r^2$

$x_{cm} = \frac{\sum m_i x_i}{\sum m_i}$

$v = r\omega$

$\vec{L} = \vec{r} \times \vec{p} = I\vec{\omega}$

$K = \frac{1}{2} I \omega^2$

$\omega = \omega_0 + \alpha t$

$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$

a = acceleration
E = energy
F = force
f = frequency
h = height
I = rotational inertia
J = impulse
K = kinetic energy
k = spring constant
ℓ = length
L = angular momentum
m = mass
P = power
p = momentum
r = radius or distance
T = period
t = time
U = potential energy
v = velocity or speed
W = work done on a system
x = position
μ = coefficient of friction
θ = angle
τ = torque
ω = angular speed
α = angular acceleration
ϕ = phase angle

$\vec{F}_s = -k\Delta\vec{x}$

$U_s = \frac{1}{2} k (\Delta x)^2$

$x = x_{\max} \cos(\omega t + \phi)$

$T = \frac{2\pi}{\omega} = \frac{1}{f}$

$T_s = 2\pi\sqrt{\frac{m}{k}}$

$T_p = 2\pi\sqrt{\frac{\ell}{g}}$

$\left|\vec{F}_G\right| = \frac{G m_1 m_2}{r^2}$

$U_G = -\frac{G m_1 m_2}{r}$

ELECTRICITY AND MAGNETISM

$\left|\vec{F}_E\right| = \frac{1}{4\pi\varepsilon_0} \left|\frac{q_1 q_2}{r^2}\right|$

$\vec{E} = \frac{\vec{F}_E}{q}$

$\oint \vec{E} \bullet d\vec{A} = \frac{Q}{\varepsilon_0}$

$E_x = -\frac{dV}{dx}$

$\Delta V = -\int \vec{E} \bullet d\vec{r}$

$V = \frac{1}{4\pi\varepsilon_0} \sum_i \frac{q_i}{r_i}$

$U_E = qV = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r}$

$\Delta V = \frac{Q}{C}$

$C = \frac{\kappa \varepsilon_0 A}{d}$

$C_p = \sum_i C_i$

$\frac{1}{C_s} = \sum_i \frac{1}{C_i}$

$I = \frac{dQ}{dt}$

$U_C = \frac{1}{2} Q\Delta V = \frac{1}{2} C (\Delta V)^2$

$R = \frac{\rho\ell}{A}$

$\vec{E} = \rho\vec{J}$

$I = Nev_d A$

$I = \frac{\Delta V}{R}$

$R_s = \sum_i R_i$

$\frac{1}{R_p} = \sum_i \frac{1}{R_i}$

$P = I\Delta V$

A = area
B = magnetic field
C = capacitance
d = distance
E = electric field
ε = emf
F = force
I = current
J = current density
L = inductance
ℓ = length
n = number of loops of wire per unit length
N = number of charge carriers per unit volume
P = power
Q = charge
q = point charge
R = resistance
r = radius or distance
t = time
U = potential or stored energy
V = electric potential
v = velocity or speed
ρ = resistivity
Φ = flux
κ = dielectric constant

$\vec{F}_M = q\vec{v} \times \vec{B}$

$\oint \vec{B} \bullet d\vec{\ell} = \mu_0 I$

$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I\, d\vec{\ell} \times \hat{r}}{r^2}$

$\vec{F} = \int I\, d\vec{\ell} \times \vec{B}$

$B_s = \mu_0 n I$

$\Phi_B = \int \vec{B} \bullet d\vec{A}$

$\varepsilon = \oint \vec{E} \bullet d\vec{\ell} = -\frac{d\Phi_B}{dt}$

$\varepsilon = -L\frac{dI}{dt}$

$U_L = \frac{1}{2} L I^2$

老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）

ADVANCED PLACEMENT PHYSICS C EQUATIONS

GEOMETRY AND TRIGONOMETRY

Rectangle

$A = bh$

Triangle

$A = \frac{1}{2}bh$

Circle

$A = \pi r^2$

$C = 2\pi r$

$s = r\theta$

Rectangular Solid

$V = \ell wh$

Cylinder

$V = \pi r^2 \ell$

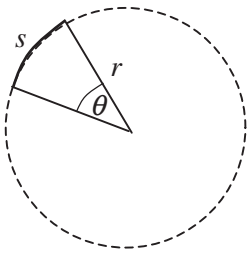
$S = 2\pi r\ell + 2\pi r^2$

Sphere

$V = \frac{4}{3}\pi r^3$

$S = 4\pi r^2$

A = area
C = circumference
V = volume
S = surface area
b = base
h = height
ℓ = length
w = width
r = radius
s = arc length
θ = angle



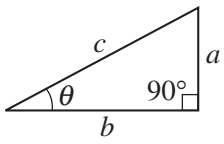
Right Triangle

$a^2 + b^2 = c^2$

$\sin\theta = \frac{a}{c}$

$\cos\theta = \frac{b}{c}$

$\tan\theta = \frac{a}{b}$



CALCULUS

$$\frac{df}{dx} = \frac{df}{du}\frac{du}{dx}$$

$$\frac{d}{dx}\left(x^n\right) = nx^{n-1}$$

$$\frac{d}{dx}\left(e^{ax}\right) = ae^{ax}$$

$$\frac{d}{dx}(\ln ax) = \frac{1}{x}$$

$$\frac{d}{dx}[\sin(ax)] = a\cos(ax)$$

$$\frac{d}{dx}[\cos(ax)] = -a\sin(ax)$$

$$\int x^n dx = \frac{1}{n+1}x^{n+1},\ n \neq -1$$

$$\int e^{ax} dx = \frac{1}{a}e^{ax}$$

$$\int \frac{dx}{x+a} = \ln|x+a|$$

$$\int \cos(ax)dx = \frac{1}{a}\sin(ax)$$

$$\int \sin(ax)dx = -\frac{1}{a}\cos(ax)$$

VECTOR PRODUCTS

$\vec{A} \bullet \vec{B} = AB\cos\theta$

$\left|\vec{A} \times \vec{B}\right| = AB\sin\theta$

老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）

PHYSICS C: MECHANICS

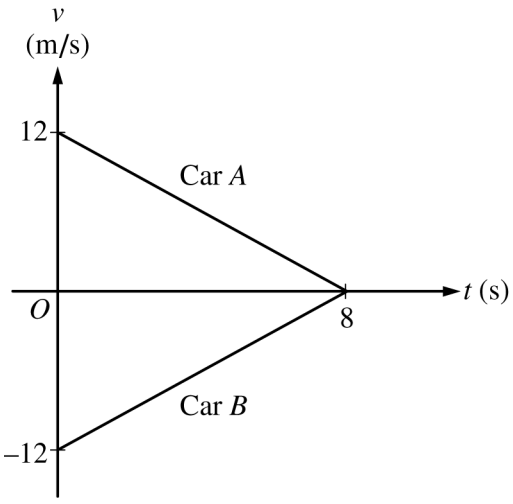
SECTION I

Time—45 minutes

35 Questions

Directions: Each of the questions or incomplete statements below is followed by five suggested answers or completions. Select the one that is best in each case and then fill in the corresponding circle on the answer sheet.

Note: To simplify calculations, you may use $g = 10\,\text{m/s}^2$ in all problems.



1. Cars *A* and *B* are moving in opposite directions along a straight road. They pass each other at time $t = 0$. Their velocities v are given as a function of time t in the graph above. The distance between the cars at $t = 8$ s is

   (A) Zero
   (B) 24 m
   (C) 48 m
   (D) 96 m
   (E) 192 m

Unauthorized copying or reuse of
老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）

2. A particle is moving along the y-axis. The particle's position as a function of time is given by $y = \alpha t^3 - \beta t + \phi$, where $\alpha = 1\ \text{m/s}^3$, $\beta = 4\ \text{m/s}$, and $\phi = 3\ \text{m}$. What is the particle's acceleration at time $t = 3.0\ \text{s}$?

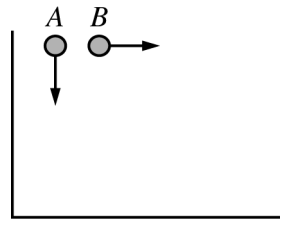
(A) $6.0\ \text{m/s}^2$

(B) $9.0\ \text{m/s}^2$

(C) $18\ \text{m/s}^2$

(D) $23\ \text{m/s}^2$

(E) $27\ \text{m/s}^2$



3. Two stones, represented in the figure above, are thrown from the same height with the same initial speed. Stone A is thrown vertically downward and stone B is thrown horizontally. If the stones are thrown at the same time and air resistance is negligible, which of the following is true?

(A) The two stones will reach the ground at the same time with the same speed.

(B) The two stones will reach the ground at the same time but with different speeds.

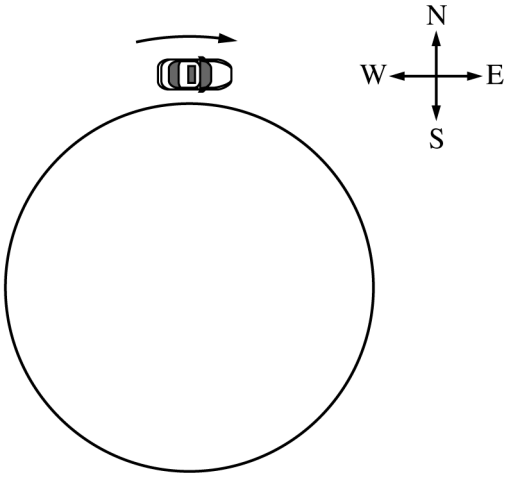
(C) Stone A will reach the ground first, but stone B will have the greater speed just before hitting the ground.

(D) Stone A will reach the ground first, but the two stones will have the same speed just before they hit the ground.

(E) Stone A will reach the ground first, and will have the greater speed just before hitting the ground.

Unauthorized copying or reuse of
老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）

Questions 4-6



Note: Figure not drawn to scale.

A car is traveling clockwise around a circular racetrack of radius 1440 m. When the car is at the northernmost point on the circle, as shown above, it has a speed of 36.0 m/s and is slowing down at a rate of 1.20 m/s^2.

4. The direction of the velocity of the car is

(A) due east
(B) south of east
(C) due south
(D) south of west
(E) due west

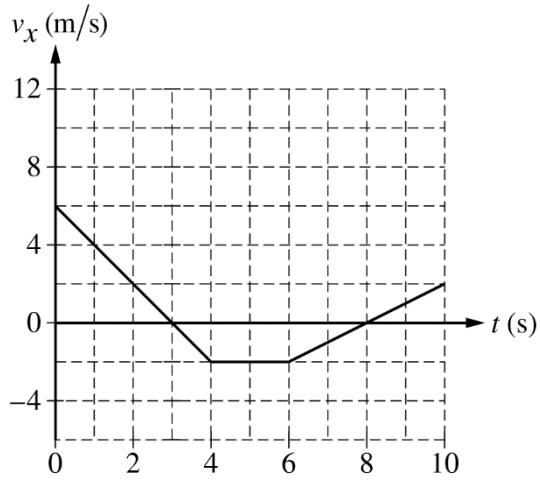
5. The direction of the acceleration of the car is

(A) due east
(B) south of east
(C) due south
(D) south of west
(E) due west

6. What is the magnitude of the acceleration of the car?

(A) 0.30 m/s^2
(B) 0.90 m/s^2
(C) 1.2 m/s^2
(D) 1.5 m/s^2
(E) 2.1 m/s^2

Questions 7-8



A car moves in a straight line along the x-axis. The velocity of the car v_x as a function of time t is shown in the graph above. The position x of the car at $t = 0$ is $x = 0$.

7. The average acceleration a_x of the car during the interval of 0 to 10 s is most nearly

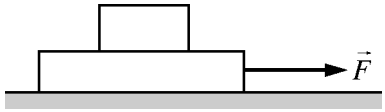
(A) −2.0 m/s^2
(B) −0.40 m/s^2
(C) +0.40 m/s^2
(D) +1.0 m/s^2
(E) +2.0 m/s^2

8. The average velocity of the car during the interval of 0 to 10 s is most nearly

(A) −1.4 m/s
(B) +0.40 m/s
(C) +1.4 m/s
(D) +1.8 m/s
(E) +4.0 m/s

Unauthorized copying or reuse of

老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）



9. Two blocks rest on a table, as shown above. The bottom block is pulled to the right by an applied force $\vec{F}$ that is strong enough so that the two blocks do not move together (i.e., they do not have the same acceleration or velocity). There is friction between the blocks, but the tabletop is frictionless. When the top block leaves the bottom block, where does it land and why?

(A) The top block will land directly below where it starts because objects at rest tend to stay at rest.
(B) The top block will land to the left of where it starts because of the static friction between the blocks.
(C) The top block will land to the left of where it starts because of the kinetic friction between the blocks.
(D) The top block will land to the right of where it starts because of the static friction between the blocks.
(E) The top block will land to the right of where it starts because of the kinetic friction between the blocks.

Unauthorized copying or reuse of
老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）

10. A sphere of mass m is dropped from the top of a building and reaches the ground before achieving terminal velocity. The force of air resistance that acts on the sphere as it falls is given by $F = -kv$, where k is a positive constant and v is the velocity of the sphere. What happens to the magnitude of the sphere's velocity and acceleration, and to the distance it falls during each second, as the sphere approaches the ground?

	Magnitude of Velocity	Magnitude of Acceleration	Distance of Fall Each Second
(A)	Increases	Increases	Increases
(B)	Increases	Decreases	Increases
(C)	Increases	Decreases	Decreases
(D)	Decreases	Increases	Decreases
(E)	Decreases	Decreases	Increases

Unauthorized copying or reuse of
老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）

Questions 11-12

An object of mass 0.5 kg is given an initial velocity and then slides across a horizontal surface. The object experiences a resistive force that is a function of velocity. The velocity v of the object as a function of time t is given by $v(t) = \alpha e^{-\beta t}$, where $\alpha = 2$ m/s and $\beta = 3\ \text{s}^{-1}$.

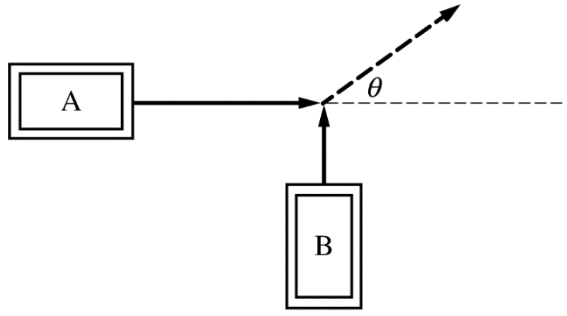
11. Which of the following is a correct expression for the net force, in newtons, exerted on the object as a function of time?

(A) $-6e^{-3t}$
(B) $-3e^{-3t}$
(C) e^{-3t}
(D) $2e^{-3t}$
(E) $\dfrac{2}{3\left(1-e^{-3t}\right)}$

12. The energy dissipated due to the resistive force after a very long time is most nearly

(A) 0.5 J
(B) 1 J
(C) 2 J
(D) 4 J
(E) infinity

Questions 13-14



Top View

Cart A is traveling east when it collides with cart B, which is traveling north. Cart A has a mass of 3.05 kg, and cart B has a mass of 2.10 kg. The two carts travel together as a single object on a horizontal surface at an angle θ relative to due east, as shown above.

13. In one trial, the initial speed of cart A is 2.5 m/s and the initial speed of cart B is 1.5 m/s. The angle θ relative to east that the carts travel after the collision is most nearly

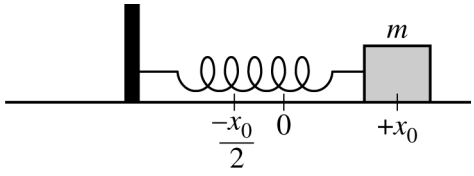
(A) 22°
(B) 36°
(C) 45°
(D) 54°
(E) 62°

14. In another trial, the speed of the carts immediately after the collision is 0.60 m/s, and the carts slide 0.24 m on the horizontal surface before coming to rest. The coefficient of kinetic friction between the sliding carts and the surface is most nearly

(A) 0.08
(B) 0.13
(C) 0.19
(D) 0.25
(E) 0.75

Unauthorized copying or reuse of
老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）

Questions 15-17



A block of mass m is on a rough horizontal surface and is attached to a spring with spring constant k. The coefficient of kinetic friction between the surface and the block is μ. When the block is at position $x = 0$, the spring is at its unstretched length. The block is pulled to position $x = +x_0$, as shown above, and released from rest. The block then travels to the left and passes through $x = 0$ before coming momentarily to rest at position $x = -x_0/2$.

15. Which of the following is a correct expression for the kinetic energy of the block as it first travels through position $x = 0$?

(A) 0

(B) $kx_0^2/2$

(C) $kx_0^2/2 - \mu mgx_0$

(D) $kx_0^2/2 - 3\mu mgx_0/2$

(E) $kx_0^2/2 - 2\mu mgx_0$

16. Which of the following is a correct expression for the coefficient of kinetic friction μ?

(A) $\frac{kx_0}{4mg}$

(B) $\frac{kx_0}{2mg}$

(C) $\frac{3kx_0}{4mg}$

(D) $\frac{kx_0}{mg}$

(E) $\frac{2kx_0}{mg}$

17. Which of the following is a differential equation that could be used to solve for the block's position x as a function of time t when it is moving to the left?

(A) $m\frac{d^2x}{dt^2} = kx + \mu mg$

(B) $m\frac{d^2x}{dt^2} = kx - \mu mg$

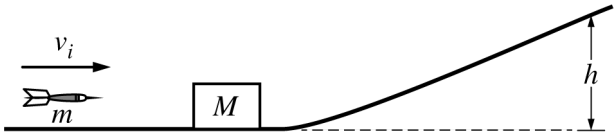
(C) $m\frac{d^2x}{dt^2} = -kx + \mu mg$

(D) $m\frac{d^2x}{dt^2} = -kx - \mu mg$

(E) $m\frac{d^2x}{dt^2} = kx$

Unauthorized copying or reuse of
老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）

Questions 18-19



In the diagram above, a block of mass M is initially at rest on a horizontal surface at the base of an inclined plane. The surface and plane have negligible friction. The block is struck by a projectile of mass m traveling with a horizontal velocity v_i. The projectile becomes embedded in the block, and they move together to the right with speed v_f.

18. Which of the following is a correct expression for v_f?

(A) $\sqrt{gh}$

(B) $\sqrt{v_i^2 + 2gh}$

(C) $\frac{m}{(m+M)}v_i$

(D) $\frac{m}{M}v_i$

(E) $\frac{M}{m}v_i$

19. The block and projectile smoothly transition onto the inclined plane. Which of the following is a correct expression for the maximum height that the block moves up the inclined plane in terms of v_f?

(A) $\frac{v_f^2}{2g}$

(B) $\frac{v_f}{\sqrt{2g}}$

(C) $\frac{Mv_f^2}{2mg}$

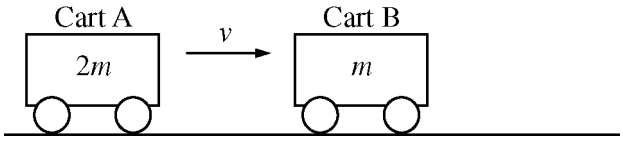
(D) $\frac{2g}{v_f^2}$

(E) $\frac{2g}{v_f}$

Unauthorized copying or reuse of
老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）

20. The net force F acting on an object that moves along a straight line is given as a function of time t by $F(t) = \kappa t^2 + \tau$, where $\kappa = 1\ \text{N/s}^2$ and $\tau = 1\ \text{N}$. What is the change in momentum of the object from $t = 0$ s to $t = 3$ s?

(A) 6 kg•m/s
(B) 10 kg•m/s
(C) 12 kg•m/s
(D) 30 kg•m/s
(E) It cannot be determined without knowing the initial momentum of the object.



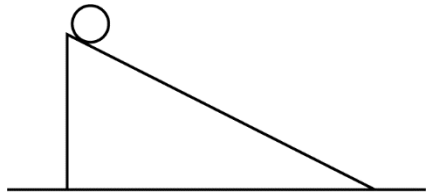
21. Cart A of mass $2m$ is moving with velocity v to the right on a horizontal frictionless track, as shown above, when it collides with cart B of mass m. Cart B is initially at rest, and the collision is perfectly elastic. Which of the following best describes the motion of the carts immediately after the collision?

(A) Cart A is moving to the left, and cart B is moving to the right.
(B) Cart A is moving to the left, and cart B remains stationary.
(C) Cart A is stationary, and cart B is moving to the right.
(D) Both carts move to the right, and they are stuck together.
(E) Both carts move to the right, but they are not stuck together.

Unauthorized copying or reuse of
老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）

22. A ball of mass m is dropped from rest at a height h and collides elastically with the floor, rebounding to its original height. What is the magnitude of the net impulse on the ball during the collision with the floor?

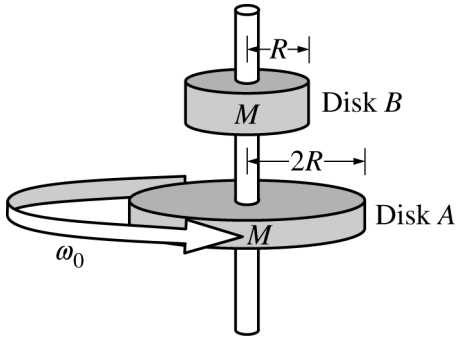
(A) Zero
(B) $m\sqrt{gh}$
(C) $m\sqrt{2gh}$
(D) $m\sqrt{4gh}$
(E) $m\sqrt{8gh}$



23. A sphere starts from rest at the top of a ramp, as shown above. It rolls without slipping down the ramp. The potential energy of the sphere-Earth system is zero at the bottom of the ramp. Which of the following is true of the sphere when it reaches the bottom of the ramp?

(A) Its rotational kinetic energy equals the initial potential energy of the sphere-Earth system.
(B) Its translational kinetic energy equals the initial potential energy of the sphere-Earth system.
(C) Its translational kinetic energy and rotational kinetic energy are equal.
(D) The sum of its translational kinetic energy and rotational kinetic energy equals the initial potential energy of the sphere-Earth system.
(E) The sum of its translational kinetic energy and rotational kinetic energy equals the energy lost because of friction.

Unauthorized copying or reuse of
老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）



24. Two horizontal disks of mass M have the radii shown above. Disk A is attached to an axle of negligible mass spinning freely with angular velocity ω_0. Disk B, not attached to the axle and initially held at rest, is released and drops down onto disk A. When both disks spin together without slipping, the angular velocity ω_f of the disks is

(A) $\frac{1}{3}\omega_0$

(B) $\frac{1}{2}\omega_0$

(C) $\frac{2}{3}\omega_0$

(D) $\frac{4}{5}\omega_0$

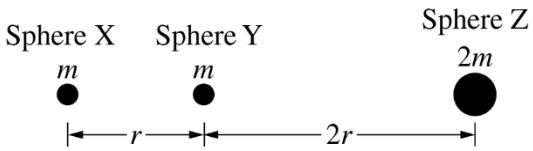
(E) $\frac{2}{\sqrt{5}}\omega_0$

25. A satellite is in a circular orbit such that it stays directly over the same point on Earth's equator. Which of the following must be true for the satellite?

I. It must have a specific mass.
II. It must have a specific altitude.
III. It must have a specific angular velocity.

(A) I only
(B) II only
(C) I and III only
(D) II and III only
(E) I, II, and III

Unauthorized copying or reuse of
老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）



26. Spheres X, Y, and Z have the masses and locations indicated in the figure above. What is the magnitude of the net gravitational force on sphere X due to the other two spheres?

(A) $\frac{Gm^2}{2r^2}$

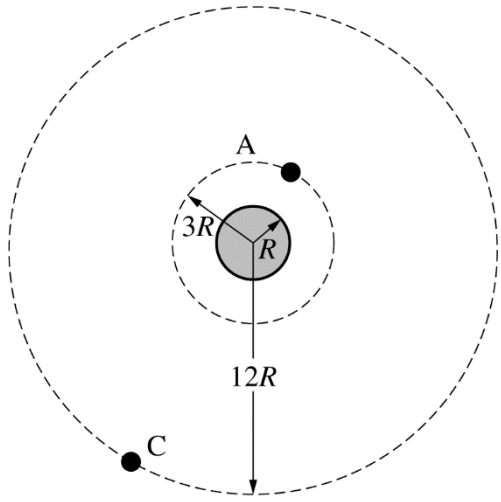
(B) $\frac{Gm^2}{r^2}$

(C) $\frac{11Gm^2}{9r^2}$

(D) $\frac{5Gm^2}{4r^2}$

(E) $\frac{2Gm^2}{r^2}$

Questions 27-28



Note: Figure not drawn to scale.

Two identical satellites orbit a planet of radius R in circular orbits A and C of radii $3R$ and $12R$, respectively, as shown above.

27. How does the magnitude of the gravitational force F_A between the planet and satellite in orbit A compare to the magnitude of the gravitational force F_C between the planet and satellite in orbit C?

(A) $F_A = 2F_C$

(B) $F_A = 3F_C$

(C) $F_A = 4F_C$

(D) $F_A = 12F_C$

(E) $F_A = 16F_C$

28. The speed of the satellite in orbit A is v_A. The speed of the satellite in orbit C is v_C. The ratio v_A/v_C is

(A) 1/2

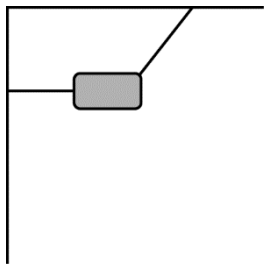
(B) 1/1

(C) 2/1

(D) 4/1

(E) 12/1

Unauthorized copying or reuse of
老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）

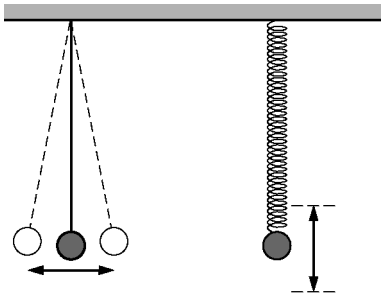


29. At the surface of Earth, an object is suspended by two cords. One cord is horizontal and one cord is at an angle to the horizontal, as shown in the figure above. The tension in the horizontal cord is T_H. If the assembly is moved to the surface of a planet with the same average density and twice the radius of Earth, the new tension in the horizontal cord will be

(A) $T_H/2$
(B) $T_H/4$
(C) T_H
(D) $2T_H$
(E) $4T_H$

30. A space shuttle has a mass of $90{,}000$ kg. In order to stay in a circular orbit, it must have a velocity of 8000 m/s. The pilot discovers that the shuttle has slowed down to 7900 m/s, and the shuttle's speed needs to increase. If the thrusters exert a constant force of $50{,}000$ N, how long do the thrusters have to exert this force in order to return the shuttle to orbital velocity?

(A) 30 s
(B) 60 s
(C) 120 s
(D) 180 s
(E) 240 s



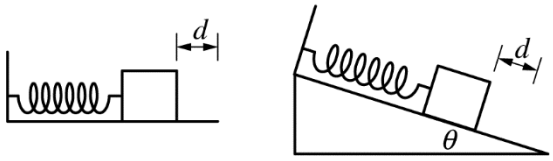
31. A pendulum and a spring both have a 1 kg sphere attached to their ends and have the same length when in equilibrium, as shown in the figure above. They both oscillate with the same period. If the 1 kg spheres are replaced with 2 kg spheres and the amplitudes of oscillation are unchanged, which of the following is true about the resultant period of oscillation for each?

	Pendulum	Spring
(A)	Remains the same	Decreases
(B)	Remains the same	Increases
(C)	Remains the same	Remains the same
(D)	Increases	Remains the same
(E)	Increases	Increases

Unauthorized copying or reuse of
老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）

Questions 32-34

System A System B



Systems A and B contain identical ideal springs and identical blocks that can slide along a surface of negligible friction. In system A, the surface is horizontal. In system B, the surface makes an angle θ with the horizontal. Initially, both blocks are at rest and in equilibrium. Each block is then pulled the same distance d in the direction shown in the figures and released from rest at $t = 0$.

32. After the block in system A is released from rest, the time for the block to first reach a maximum speed is Δt_A. After the block in system B is released, the time for the block to first reach a maximum speed is

(A) Δt_A
(B) $\Delta t_A (\sin\theta)$
(C) $\Delta t_A / (\sin\theta)$
(D) $\Delta t_A (\cos\theta)$
(E) $\Delta t_A / (\cos\theta)$

33. For system A, when the block is halfway between its release position and its equilibrium position, the block's kinetic energy is K and the elastic potential energy of the spring-block system is U. The ratio K/U is

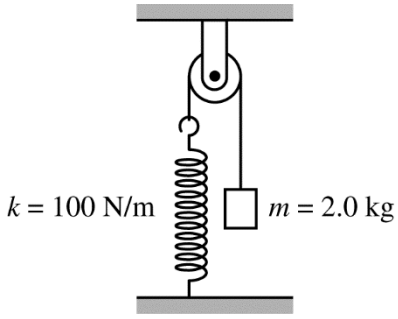
(A) 1/3
(B) 1/2
(C) 1/1
(D) 2/1
(E) 3/1

34. A student wants to use an apparatus similar to system B to measure the acceleration due to gravity g. If the mass of the block, the force constant of the spring, and the angle of the incline are known, what additional data must be measured to determine an experimental value for g ?

I. The stretch of the spring at the equilibrium position
II. The speed of the block as it passes the equilibrium position
III. The time interval between two consecutive passes through the equilibrium position

(A) I only
(B) II only
(C) I and II
(D) II and III
(E) I and III

Unauthorized copying or reuse of
老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）



35. A 2.0 kg block is attached to a string that passes over a pulley and is attached to an ideal spring of spring constant $k = 100\ \text{N/m}$, as shown above. The pulley and string have negligible mass, and there is negligible friction in the pulley. The block is held in place with the spring at its original unstretched length and then released from rest. The amplitude of the resulting oscillation is most nearly

(A) 4.0 cm
(B) 2.0 cm
(C) 10 cm
(D) 20 cm
(E) 40 cm

Unauthorized copying or reuse of
老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）

AP® Physics C: Mechanics Exam

SECTION II: Free Response

2019

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

At a Glance

Total Time
45 minutes
Number of Questions
3
Percent of Total Score
50%
Writing Instrument
Either pencil or pen with black or dark blue ink
Electronic Device
Calculator allowed
Weight
The questions are weighted equally.

IMPORTANT Identification Information

PLEASE PRINT WITH PEN:

1. First two letters of your last name ☐☐
   First letter of your first name ☐
2. Date of birth
   ☐☐ Month ☐☐ Day ☐☐☐☐ Year
3. Six-digit school code
   ☐☐☐☐☐☐
4. Unless I check the box below, I grant the College Board the unlimited right to use, reproduce, and publish my free-response materials, both written and oral, for educational research and instructional purposes. My name and the name of my school will not be used in any way in connection with my free-response materials. I understand that I am free to mark "No" with no effect on my score or its reporting.
   No, I do not grant the College Board these rights. ☐

Instructions

The questions for Section II are printed in this booklet. You may use any blank space in the booklet for scratch work, but you must write your answers in the spaces provided for each answer. A table of information and lists of equations that may be helpful are in the booklet. Calculators, rulers, and straightedges may be used in this section.

All final numerical answers should include appropriate units. Credit for your work depends on demonstrating that you know which physical principles would be appropriate to apply in a particular situation. Therefore, you should show your work for each part in the space provided after that part. If you need more space, be sure to clearly indicate where you continue your work. Credit will be awarded only for work that is clearly designated as the solution to a specific part of a question. Credit also depends on the quality of your solutions and explanations, so you should show your work.

Write clearly and legibly. Cross out any errors you make; erased or crossed-out work will not be scored. You may lose credit for incorrect work that is not crossed out.

Manage your time carefully. You may proceed freely from one question to the next. You may review your responses if you finish before the end of the exam is announced.

Form I
Form Code 4PBP4-S

老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）

ADVANCED PLACEMENT PHYSICS C TABLE OF INFORMATION

CONSTANTS AND CONVERSION FACTORS

Proton mass,	$m_p = 1.67 \times 10^{-27}$ kg	Electron charge magnitude,	$e = 1.60 \times 10^{-19}$ C
Neutron mass,	$m_n = 1.67 \times 10^{-27}$ kg	1 electron volt,	1 eV $= 1.60 \times 10^{-19}$ J
Electron mass,	$m_e = 9.11 \times 10^{-31}$ kg	Speed of light,	$c = 3.00 \times 10^{8}$ m/s
Avogadro's number,	$N_0 = 6.02 \times 10^{23}$ mol^{-1}	Universal gravitational constant,	$G = 6.67 \times 10^{-11}$ $\left(\text{N}\cdot\text{m}^2\right)/\text{kg}^2$
Universal gas constant,	$R = 8.31$ J/(mol·K)	Acceleration due to gravity at Earth's surface,	$g = 9.8$ m/s^2
Boltzmann's constant,	$k_B = 1.38 \times 10^{-23}$ J/K		

1 unified atomic mass unit,	1 u $= 1.66 \times 10^{-27}$ kg $= 931$ MeV/c^2
Planck's constant,	$h = 6.63 \times 10^{-34}$ J·s $= 4.14 \times 10^{-15}$ eV·s
	$hc = 1.99 \times 10^{-25}$ J·m $= 1.24 \times 10^{3}$ eV·nm
Vacuum permittivity,	$\varepsilon_0 = 8.85 \times 10^{-12}$ C$^2/\left(\text{N}\cdot\text{m}^2\right)$
Coulomb's law constant,	$k = 1/(4\pi\varepsilon_0) = 9.0 \times 10^{9}$ $\left(\text{N}\cdot\text{m}^2\right)/\text{C}^2$
Vacuum permeability,	$\mu_0 = 4\pi \times 10^{-7}$ (T·m)/A
Magnetic constant,	$k' = \mu_0/(4\pi) = 1 \times 10^{-7}$ (T·m)/A
1 atmosphere pressure,	1 atm $= 1.0 \times 10^{5}$ N/m^2 $= 1.0 \times 10^{5}$ Pa

UNIT SYMBOLS	meter,	m	mole,	mol	watt,	W	farad,	F
	kilogram,	kg	hertz,	Hz	coulomb,	C	tesla,	T
	second,	s	newton,	N	volt,	V	degree Celsius,	°C
	ampere,	A	pascal,	Pa	ohm,	Ω	electron volt,	eV
	kelvin,	K	joule,	J	henry,	H		

PREFIXES		
Factor	Prefix	Symbol
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p

VALUES OF TRIGONOMETRIC FUNCTIONS FOR COMMON ANGLES							
θ	0°	30°	37°	45°	53°	60°	90°
$\sin\theta$	0	1/2	3/5	$\sqrt{2}/2$	4/5	$\sqrt{3}/2$	1
$\cos\theta$	1	$\sqrt{3}/2$	4/5	$\sqrt{2}/2$	3/5	1/2	0
$\tan\theta$	0	$\sqrt{3}/3$	3/4	1	4/3	$\sqrt{3}$	∞

The following assumptions are used in this exam.

I. The frame of reference of any problem is inertial unless otherwise stated.
II. The direction of current is the direction in which positive charges would drift.
III. The electric potential is zero at an infinite distance from an isolated point charge.
IV. All batteries and meters are ideal unless otherwise stated.
V. Edge effects for the electric field of a parallel plate capacitor are negligible unless otherwise stated.

老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）

ADVANCED PLACEMENT PHYSICS C EQUATIONS

MECHANICS

$v_x = v_{x0} + a_x t$

$x = x_0 + v_{x0} t + \frac{1}{2} a_x t^2$

$v_x^2 = {v_{x0}}^2 + 2a_x (x - x_0)$

$\vec{a} = \frac{\sum \vec{F}}{m} = \frac{\vec{F}_{net}}{m}$

$\vec{F} = \frac{d\vec{p}}{dt}$

$\vec{J} = \int \vec{F}\, dt = \Delta\vec{p}$

$\vec{p} = m\vec{v}$

$\left|\vec{F}_f\right| \le \mu \left|\vec{F}_N\right|$

$\Delta E = W = \int \vec{F} \bullet d\vec{r}$

$K = \frac{1}{2} m v^2$

$P = \frac{dE}{dt}$

$P = \vec{F} \bullet \vec{v}$

$\Delta U_g = mg\Delta h$

$a_c = \frac{v^2}{r} = \omega^2 r$

$\vec{\tau} = \vec{r} \times \vec{F}$

$\vec{\alpha} = \frac{\sum \vec{\tau}}{I} = \frac{\vec{\tau}_{net}}{I}$

$I = \int r^2 dm = \sum m r^2$

$x_{cm} = \frac{\sum m_i x_i}{\sum m_i}$

$v = r\omega$

$\vec{L} = \vec{r} \times \vec{p} = I\vec{\omega}$

$K = \frac{1}{2} I \omega^2$

$\omega = \omega_0 + \alpha t$

$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$

a = acceleration
E = energy
F = force
f = frequency
h = height
I = rotational inertia
J = impulse
K = kinetic energy
k = spring constant
ℓ = length
L = angular momentum
m = mass
P = power
p = momentum
r = radius or distance
T = period
t = time
U = potential energy
v = velocity or speed
W = work done on a system
x = position
μ = coefficient of friction
θ = angle
τ = torque
ω = angular speed
α = angular acceleration
ϕ = phase angle

$\vec{F}_s = -k\Delta\vec{x}$

$U_s = \frac{1}{2} k (\Delta x)^2$

$x = x_{\max} \cos(\omega t + \phi)$

$T = \frac{2\pi}{\omega} = \frac{1}{f}$

$T_s = 2\pi\sqrt{\frac{m}{k}}$

$T_p = 2\pi\sqrt{\frac{\ell}{g}}$

$\left|\vec{F}_G\right| = \frac{G m_1 m_2}{r^2}$

$U_G = -\frac{G m_1 m_2}{r}$

ELECTRICITY AND MAGNETISM

$\left|\vec{F}_E\right| = \frac{1}{4\pi\varepsilon_0} \left|\frac{q_1 q_2}{r^2}\right|$

$\vec{E} = \frac{\vec{F}_E}{q}$

$\oint \vec{E} \bullet d\vec{A} = \frac{Q}{\varepsilon_0}$

$E_x = -\frac{dV}{dx}$

$\Delta V = -\int \vec{E} \bullet d\vec{r}$

$V = \frac{1}{4\pi\varepsilon_0} \sum_i \frac{q_i}{r_i}$

$U_E = qV = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r}$

$\Delta V = \frac{Q}{C}$

$C = \frac{\kappa \varepsilon_0 A}{d}$

$C_p = \sum_i C_i$

$\frac{1}{C_s} = \sum_i \frac{1}{C_i}$

$I = \frac{dQ}{dt}$

$U_C = \frac{1}{2} Q\Delta V = \frac{1}{2} C (\Delta V)^2$

$R = \frac{\rho\ell}{A}$

$\vec{E} = \rho\vec{J}$

$I = Nev_d A$

$I = \frac{\Delta V}{R}$

$R_s = \sum_i R_i$

$\frac{1}{R_p} = \sum_i \frac{1}{R_i}$

$P = I\Delta V$

A = area
B = magnetic field
C = capacitance
d = distance
E = electric field
ε = emf
F = force
I = current
J = current density
L = inductance
ℓ = length
n = number of loops of wire per unit length
N = number of charge carriers per unit volume
P = power
Q = charge
q = point charge
R = resistance
r = radius or distance
t = time
U = potential or stored energy
V = electric potential
v = velocity or speed
ρ = resistivity
Φ = flux
κ = dielectric constant

$\vec{F}_M = q\vec{v} \times \vec{B}$

$\oint \vec{B} \bullet d\vec{\ell} = \mu_0 I$

$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I\, d\vec{\ell} \times \hat{r}}{r^2}$

$\vec{F} = \int I\, d\vec{\ell} \times \vec{B}$

$B_s = \mu_0 n I$

$\Phi_B = \int \vec{B} \bullet d\vec{A}$

$\varepsilon = \oint \vec{E} \bullet d\vec{\ell} = -\frac{d\Phi_B}{dt}$

$\varepsilon = -L\frac{dI}{dt}$

$U_L = \frac{1}{2} L I^2$

老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）

ADVANCED PLACEMENT PHYSICS C EQUATIONS

GEOMETRY AND TRIGONOMETRY

Rectangle

$A = bh$

Triangle

$A = \frac{1}{2}bh$

Circle

$A = \pi r^2$

$C = 2\pi r$

$s = r\theta$

Rectangular Solid

$V = \ell wh$

Cylinder

$V = \pi r^2 \ell$

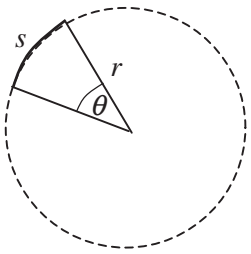
$S = 2\pi r\ell + 2\pi r^2$

Sphere

$V = \frac{4}{3}\pi r^3$

$S = 4\pi r^2$

A = area
C = circumference
V = volume
S = surface area
b = base
h = height
ℓ = length
w = width
r = radius
s = arc length
θ = angle



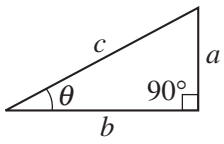
Right Triangle

$a^2 + b^2 = c^2$

$\sin\theta = \frac{a}{c}$

$\cos\theta = \frac{b}{c}$

$\tan\theta = \frac{a}{b}$



CALCULUS

$$\frac{df}{dx} = \frac{df}{du}\frac{du}{dx}$$

$$\frac{d}{dx}\left(x^n\right) = nx^{n-1}$$

$$\frac{d}{dx}\left(e^{ax}\right) = ae^{ax}$$

$$\frac{d}{dx}(\ln ax) = \frac{1}{x}$$

$$\frac{d}{dx}[\sin(ax)] = a\cos(ax)$$

$$\frac{d}{dx}[\cos(ax)] = -a\sin(ax)$$

$$\int x^n dx = \frac{1}{n+1}x^{n+1},\ n \neq -1$$

$$\int e^{ax} dx = \frac{1}{a}e^{ax}$$

$$\int \frac{dx}{x+a} = \ln|x+a|$$

$$\int \cos(ax)dx = \frac{1}{a}\sin(ax)$$

$$\int \sin(ax)dx = -\frac{1}{a}\cos(ax)$$

VECTOR PRODUCTS

$\vec{A} \bullet \vec{B} = AB\cos\theta$

$\left|\vec{A} \times \vec{B}\right| = AB\sin\theta$

老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）

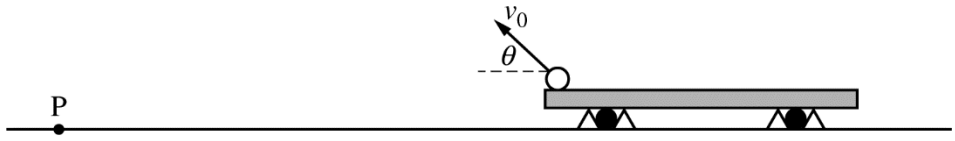
PHYSICS C: MECHANICS

SECTION II

Time—45 minutes

3 Questions

Directions: Answer all three questions. The suggested time is about 15 minutes for answering each of the questions, which are worth 15 points each. The parts within a question may not have equal weight. Show all your work in this booklet in the spaces provided after each part.

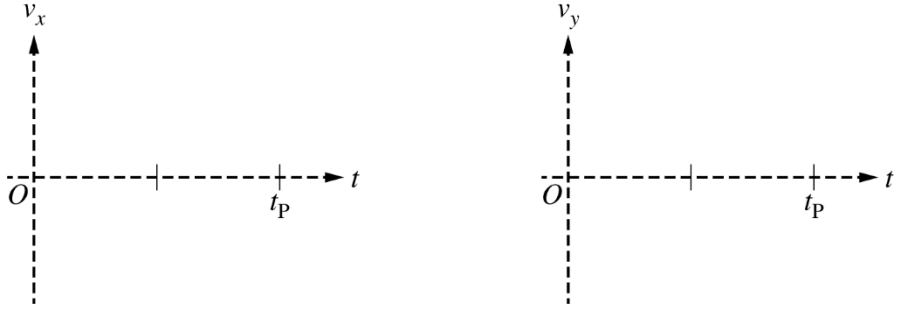


Note: Figure not drawn to scale.

1. A projectile is launched from the back of a cart of mass m that is held at rest, as shown above. At time $t = 0$, the projectile leaves the cart with speed v_0 at an angle θ above the horizontal. The projectile lands at point P. Assume that the starting height of the projectile above the ground is negligible compared to the maximum height reached by the projectile and the horizontal distance traveled.

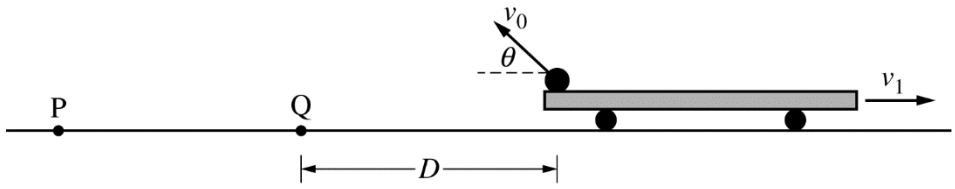
   (a) Derive an expression for the time t_P at which the projectile reaches point P. Express your answer in terms of v_0, θ, and physical constants, as appropriate.

   (b) On the axes below, sketch the horizontal component v_x and the vertical component v_y of the velocity of the projectile as a function of time t from $t = 0$ until $t = t_P$. Explicitly label the vertical intercepts with algebraic expressions.



Unauthorized copying or reuse of any part of this page is illegal.

老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）



Note: Figure not drawn to scale.

The projectile is again launched from the same position, but with the cart traveling to the right with speed v_1 relative to the ground, as shown above. The projectile again leaves the cart with speed v_0 relative to the cart at an angle θ above the horizontal, and the projectile lands at point Q, which is a horizontal distance D from the launching point. Express your answers in terms of v_0, θ, and physical constants, as appropriate.

(c) Give a physical reason why the projectile lands at point Q, which is not as far from the launch position as point P is, and explain how that physical reason affects the flight of the projectile.

(d) Derive an expression for v_1. Express your answer in terms of v_0, θ, D, and physical constants, as appropriate.

After the launch, the cart's speed is v_2. Beginning at time $t = 0$, the cart experiences a braking force of $F = -bv$, where b is a positive constant with units of kg/s and v is the speed of the cart. Express your answers to the following in terms of m, b, v_2, and physical constants, as appropriate.

(e)

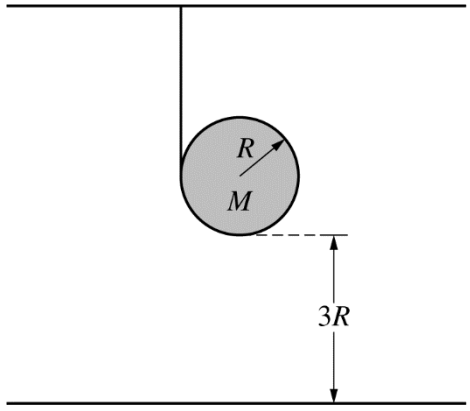
i. Using Newton's second law, write but DO NOT solve a differential equation that represents the motion of the cart while it experiences the braking force.

ii. Show that the speed $v(t)$ of the cart as a function of time is given by the equation $v(t) = v_2 e^{-bt/m}$.

iii. Derive an expression for the distance the cart travels from $t = 0$ until the time it comes to a stop.

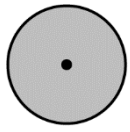
Unauthorized copying or reuse of any part of this page is illegal.

老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）



2. A thin uniform disk of mass M and radius R has a string wrapped around its edge and attached to the ceiling. The bottom of the disk is at a height $3R$ above the floor, as shown above. The disk is released from rest. The rotational inertia of a disk around its center is $I = MR^2/2$.

   (a) On the circle below that represents the disk, draw and label the forces (not components) that act on the disk. Each force must be represented by a distinct arrow starting on, and pointing away from, the disk, beginning at the point where the force is exerted on the disk. The dot is at the center of the disk.



   (b) When released from rest, the disk falls and the string unwinds. The force the string exerts on the disk is F_T, and the gravitational force exerted on the disk is F_g. Which of the following expressions correctly relates F_T and F_g as the disk falls?

   ____ $F_T < F_g$ ____ $F_T = F_g$ ____ $F_T > F_g$

   Justify your answer.

Unauthorized copying or reuse of any part of this page is illegal.

老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）

(c) Express all answers in terms of M, R, and physical constants, as appropriate.

i. Derive an expression for the acceleration a of the disk as it falls.

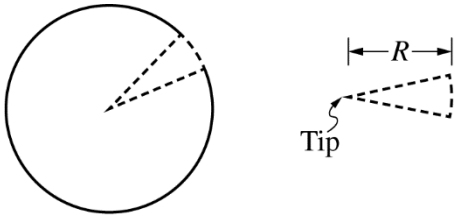
ii. Derive an expression for the time Δt that it takes the disk to reach the ground.

iii. Derive an expression for the rotational kinetic energy K_{rot} of the disk at the instant it reaches the ground.

Question 2 continues on the next page.

Unauthorized copying or reuse of any part of this page is illegal.

老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）



Note: Figure not drawn to scale.

(d) A very narrow wedge is cut out of the thin uniform disk of mass M, as shown above. If r is the distance from the tip of the wedge, then the linear mass density of the wedge can be expressed as follows:

$$\lambda(r) = \frac{Mr}{25R^2}.$$

i. Using integral calculus, derive an expression for the rotational inertia of the wedge around its tip.

ii. Derive an expression for the rotational inertia of the modified disk (i.e., the disk after the narrow wedge is cut out) around its original center.

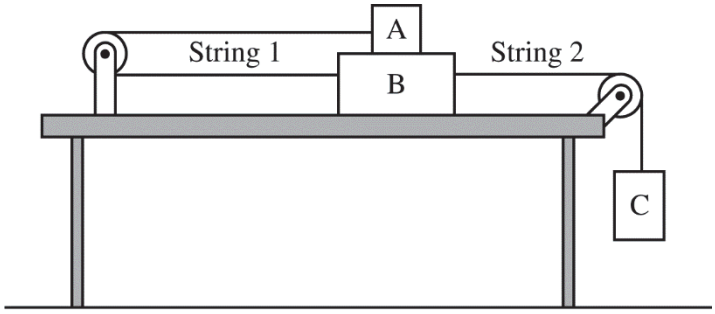
Unauthorized copying or reuse of any part of this page is illegal.

老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）

THIS PAGE MAY BE USED FOR SCRATCH WORK.

GO ON TO THE NEXT PAGE.

老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）



3. Three blocks are connected by strings that pass over pulleys of negligible mass. Block B is on a level, horizontal surface of negligible friction. Block A is on top of block B. String 1 connects blocks A and B. The coefficients of static and kinetic friction between blocks A and B are μ_s and μ_k, respectively. Block C is hanging over the end of the table and is attached to block B by string 2, as shown above. The masses of blocks A, B, and C are m_A, m_B, and m_C, respectively. When block C is released, the system remains at rest.

(a)

i. On the dot below, which represents block A, draw and label the forces (not components) that act on block A. Each force must be represented by a distinct arrow starting on, and pointing away from, the dot.

Block A

●

ii. On the dot below, which represents block B, draw and label the forces (not components) that act on block B. Each force must be represented by a distinct arrow starting on, and pointing away from, the dot.

Block B

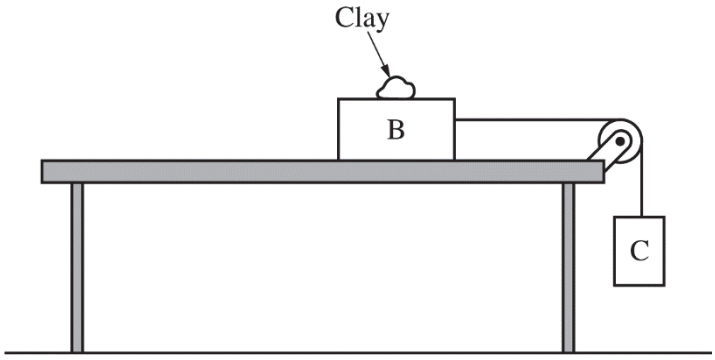
●

(b) Derive an expression for the maximum value for m_C at which the blocks will remain at rest. Express all algebraic answers in terms of μ_s, μ_k, m_A, m_B, m_C, and physical constants, as appropriate.

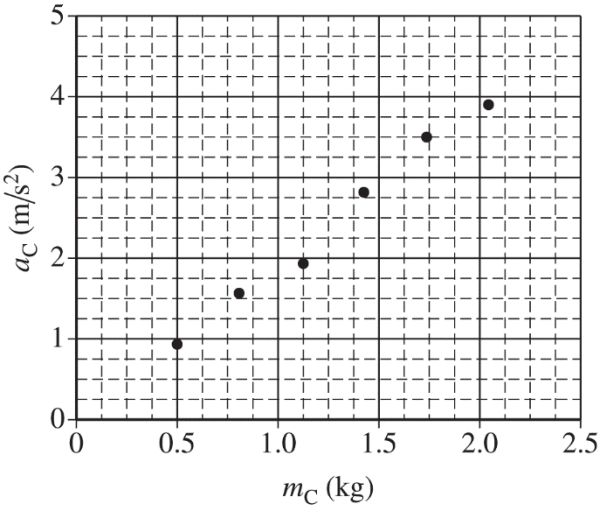
Unauthorized copying or reuse of any part of this page is illegal.

GO ON TO THE NEXT PAGE

老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）



The setup is modified, as shown in the figure above. Block A and one of the pulleys are removed, and block B remains on the table. There is still negligible friction between block B and the table. A lump of clay is added to block B. The students use Newton's second law to derive an equation for the acceleration a_C of block C. The acceleration is given by the equation $a_C = m_C g / m_{tot}$, where m_{tot} is the combined mass of the clay and the two blocks. Students use the setup shown above to experimentally determine the acceleration g due to gravity. In each trial, a student moves a small amount of clay from block B to block C and then releases the blocks from rest, recording the new values of m_C and a_C. The total mass of the clay and the two blocks is $m_{tot} = 5.0$ kg. The graph below shows a_C as a function of m_C, where m_C is now the combined mass of block C and the mass of clay added to block C.



(c)

i. Draw a best-fit line to the data points in the graph above.

ii. Use the best-fit line from part (c)(i) to calculate an experimental value for the acceleration g due to gravity.

Unauthorized copying or reuse of any part of this page is illegal.

老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）

(d) If the mass of the pulley in part (c) is significant, would the experimental value of g be greater than, less than, or equal to the value calculated in part (c)(ii) ?

____ Greater than ____ Less than ____ Equal to

Justify your answer.

A different group of students repeats the experiment, but instead of moving clay from block B to block C, they just remove a small amount of clay from block B and set it aside, away from the setup. The equation $a_C = m_C g / m_{tot}$ still applies to the new experiment.

(e) In order to provide a straight-line graph that can be used to determine an experimental value for g, what two quantities should the students now graph? Check all that apply.

____ a_c vs $\frac{1}{m_{tot}}$ ____ a_c vs m_{tot} ____ a_c vs $\frac{m_c}{m_{tot}}$

____ a_c vs m_C ____ m_c vs m_{tot} ____ m_c vs $\frac{1}{m_{tot}}$

Justify your answer.

Unauthorized copying or reuse of any part of this page is illegal.

老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）

THIS PAGE MAY BE USED FOR SCRATCH WORK.

STOP

END OF EXAM

THE FOLLOWING INSTRUCTIONS APPLY TO THE COVERS OF THE SECTION II BOOKLET.

- **MAKE SURE YOU HAVE COMPLETED THE IDENTIFICATION INFORMATION AS REQUESTED ON THE FRONT AND BACK COVERS OF THE SECTION II BOOKLET.**
- **CHECK TO SEE THAT YOUR AP NUMBER LABEL APPEARS IN THE BOX ON THE COVER.**
- **MAKE SURE YOU HAVE USED THE SAME SET OF AP NUMBER LABELS ON ALL AP EXAMS YOU HAVE TAKEN THIS YEAR.**

老师微信：liuxue119118（真题有修改过，请加微信确认是否完整，以免影响您的学习！）