AP PHYSICS C TEST

SECTION I—MECHANICS
Time: 45 minutes
35 Questions

Directions: Each of the questions or incomplete statements below is followed by 5 suggested answers or completions. Select the one that is best in each case.

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

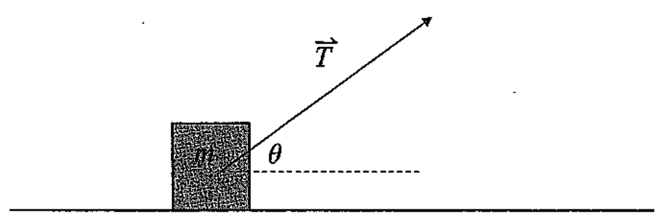
1. A 20-kg mass moving at 10 m/s decelerates uniformly to rest in 5 s. During this time, the mass has traveled a distance of

(A) 2 m (B) 50 m (C) 25 m (D) 125 m (E) 12.5 m

2. A 2-kg mass is projected straight up with an initial speed of 20 m/s. In describing the velocity and acceleration of the object, a student chooses the starting point as the origin and the positive direction as up. At the highest point of the projectile, how will the student describe the velocity and acceleration of the mass?

	Velocity	Acceleration
(A)	negative	positive
(B)	positive	negative
(C)	0	0
(D)	0	positive
(E)	0	negative

Questions 3 and 4



A mass m is pulled along a rough surface at a constant speed by a force maintained at an angle θ with the horizontal.

3. The work done by $\vec{T}$ as the mass moves a distance D is

(A) 0 (B) $TD\cos\theta$ (C) $\frac{T}{m}\cos\theta$ (D) $TD\sin\theta$ (E) $\frac{T}{m}\sin\theta$

4. The coefficient of friction is

(A) $\tan\theta$ (B) $\frac{T\cos\theta}{mg - T\sin\theta}$ (C) $\frac{T\cos\theta}{T\sin\theta + mg}$ (D) $\frac{T\sin\theta}{mg - T\cos\theta}$ (E) $\frac{T\sin\theta}{T\cos\theta + mg}$

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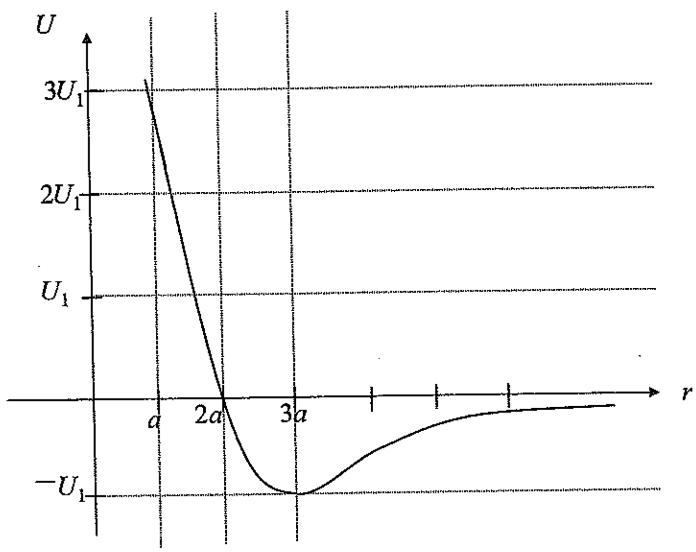
5. A satellite of mass M moves with speed v in a circular orbit of radius R around Earth. Which of the following is true?
   I. To place a larger mass in the same orbit would require a larger orbit speed.
   II. The centripetal acceleration is independent of the mass of Earth.
   III. The angular momentum of the satellite is constant.

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

6. A mass m falls from rest and experiences an air resistance force of the form $F_{air} = -bv^2$. The terminal speed of the mass is

(A) $\frac{mg}{b}$ (B) $\sqrt{\frac{mg}{b}}$ (C) $\sqrt{\frac{b}{mg}}$ (D) $\sqrt{\frac{g}{b}}$ (E) $\frac{g}{b}$

Questions 7 and 8



A mass m moves under the influence of a potential energy function given by the graph above.

7. At the point $r = 2a$, the force exerted on the mass is closest to

(A) 0 (B) $\frac{U_1}{a}$ (C) $\frac{4U_1}{a}$ (D) $\frac{3U_1}{a}$ (E) $\frac{3U_1}{2a}$

8. The maximum speed of a mass released from rest at the point $r = a$ is

(A) $\sqrt{\frac{U_1}{m}}$ (B) $\sqrt{\frac{2U_1}{m}}$ (C) $\sqrt{\frac{4U_1}{m}}$ (D) $\sqrt{\frac{6U_1}{m}}$ (E) $\sqrt{\frac{8U_1}{m}}$

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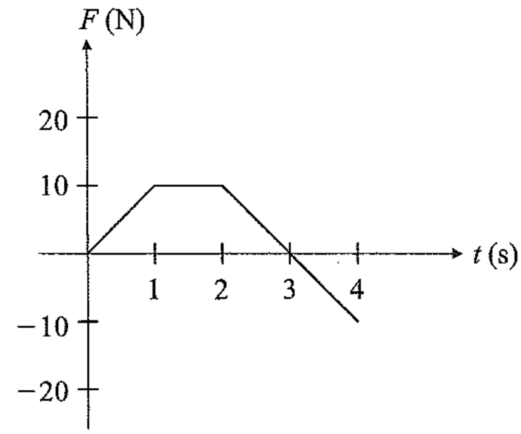
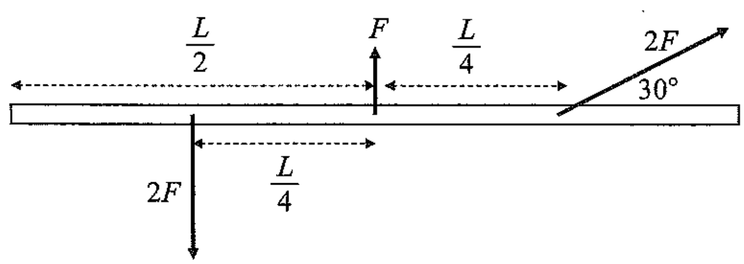


9. An object experiences the nonconstant net force shown in the figure. The change in momentum of the object over the 4 seconds that the force acts is closest to

(A) $10\ \frac{\text{kg} \cdot \text{m}}{\text{s}}$ (B) $15\ \frac{\text{kg} \cdot \text{m}}{\text{s}}$ (C) $20\ \frac{\text{kg} \cdot \text{m}}{\text{s}}$ (D) $25\ \frac{\text{kg} \cdot \text{m}}{\text{s}}$ (E) $30\ \frac{\text{kg} \cdot \text{m}}{\text{s}}$

10. A mass $6m$ moving with speed $+v$ across a smooth horizontal surface explodes into three pieces of masses m, $2m$, and $3m$, respectively. After the explosion, the mass m is stationary, and the mass $2m$ is moving with velocity $+2v$. What is the velocity of the other mass?

(A) $\frac{1}{2}v$ (B) $\frac{1}{3}v$ (C) 0 (D) $\frac{2}{3}v$ (E) $\frac{3}{2}v$



11. Three forces act on a light stick as indicated in the figure. The net torque about the center of the stick is

(A) 0 (B) $\frac{1}{2}FL$ (C) $\frac{3}{4}FL$ (D) FL (E) $2FL$

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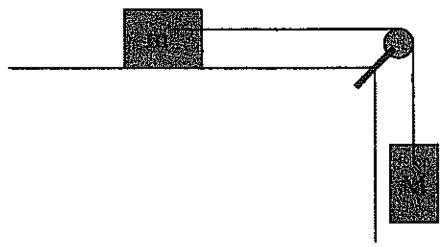

12. A mass m is pulled across a frictionless horizontal surface by a string attached to a descending mass M over a light, frictionless pulley. The tension in the string is

(A) Mg (B) $\frac{mM}{m+M}g$ (C) $\frac{m}{M}g$ (D) $\frac{M}{m}g$ (E) $\frac{mM}{M-m}g$

13. A satellite of mass m moves in a circular orbit of radius R about the Earth. The angular momentum of the satellite about the center of the Earth has a magnitude

(A) $m\sqrt{\frac{M_eR}{G}}$ (B) $m\sqrt{\frac{GR}{M_e}}$ (C) $m\sqrt{\frac{GM_e}{R}}$ (D) $m\sqrt{GM_eR}$ (E) $m\sqrt{\frac{R}{GM_e}}$

14. A physical pendulum oscillates through small angles about the vertical with the angle, measured in radians, obeying the differential equation $\frac{d^2\theta}{dt^2} = -4\pi\theta$. The period of the oscillations in seconds is

(A) $\frac{1}{8\pi}$ (B) 8π (C) $\frac{1}{4}$ (D) $\sqrt{\pi}$ (E) 4π

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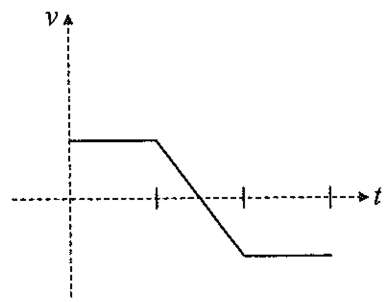
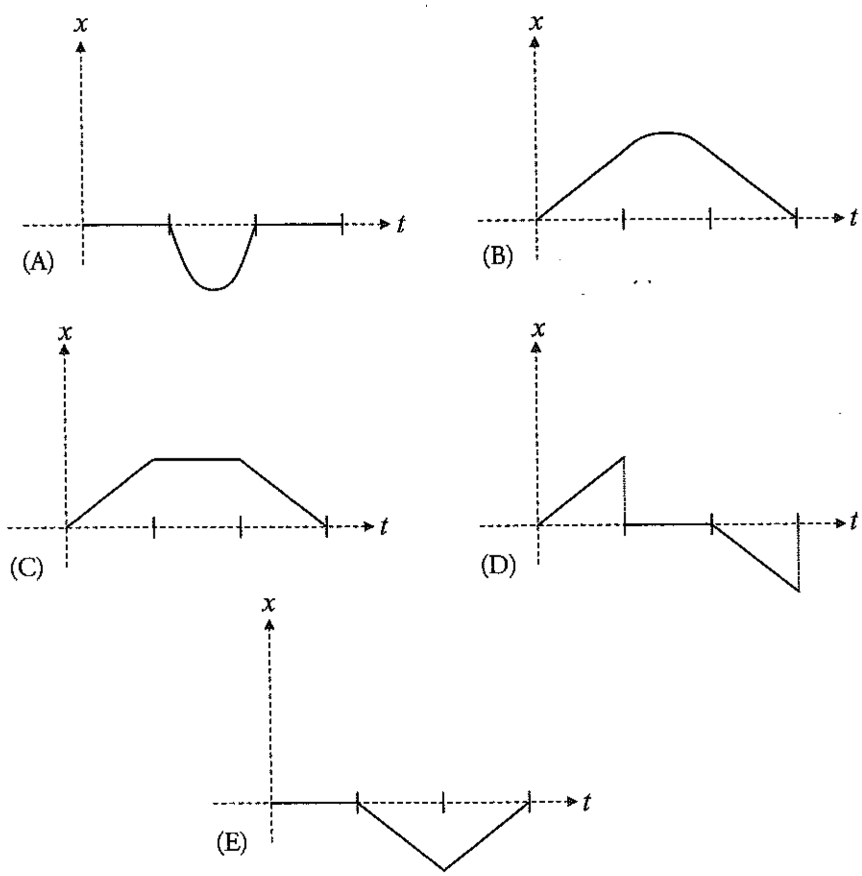


15. An object moves in one dimension with a velocity vs. time graph as shown above. The graph that best represents the displacement of the object over the same time interval is which of the following?



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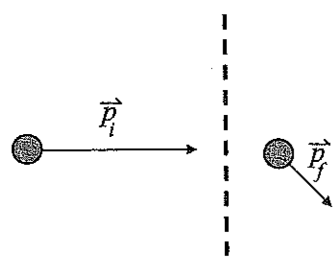
16. A mass m is projected with a velocity of magnitude 50 m/s, making an angle of 37° with the horizontal, the x-axis. At the highest point, which of the following could be values for the magnitude of the velocity components and the vertical acceleration component?

	v_x	v_y	a_y
(A)	30 m/s	40 m/s	10 m/s^2
(B)	40 m/s	0	10 m/s^2
(C)	30 m/s	0	10 m/s^2
(D)	40 m/s	0	0
(E)	40 m/s	30 m/s	10 m/s^2



17. A mass with momentum $\vec{p}_i$ is acted upon by a force, causing the momentum to change to $\vec{p}_f$. The vector that best represents the impulse delivered by the force during the change is

(A) ↖ (B) ↗ (C) ↙ (D) ↘ (E) ←

Questions 18 and 19

A 4 kg mass oscillates on a smooth surface at the end of a horizontal spring according to the equation $x(t) = 0.5 \cos\left(6\pi t + \frac{\pi}{8}\right)$, with x measured in meters.

18. The value of the spring constant is

(A) 24π (B) $\frac{\pi^2}{4}$ (C) $\frac{\pi}{2}$ (D) $144\pi^2$ (E) $36\pi^2$

19. The maximum acceleration of the mass is

(A) 3π (B) $18\pi^2$ (C) $\frac{\pi}{16}$ (D) $\frac{\pi^2}{128}$ (E) $\frac{9}{2}\pi^2$

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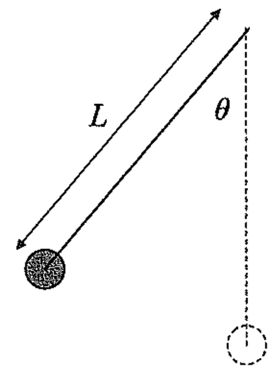
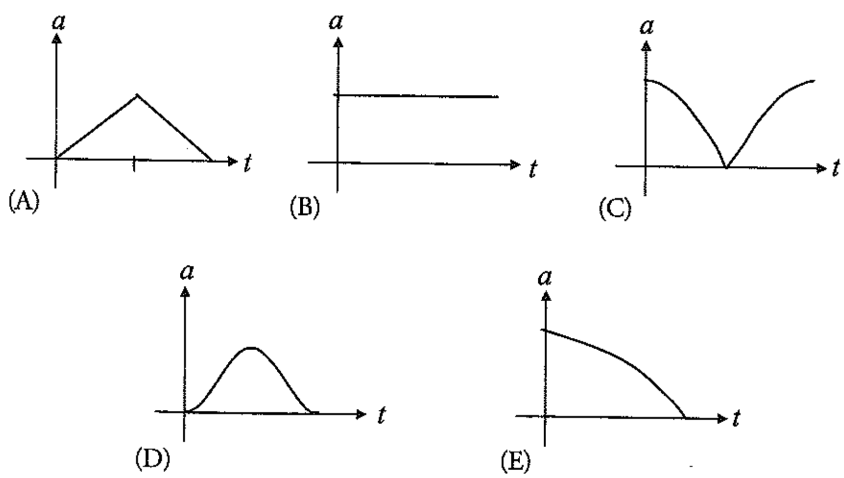
Questions 20–22



A simple pendulum initially making an angle θ with the vertical is released from rest.



20. During the first half-period of the motion, the graph that best represents the centripetal acceleration of the mass as a function of time is

(A) A (B) B (C) C (D) D (E) E

21. During the first half-period of the motion, the graph that best represents the magnitude of the tangential acceleration of the mass as a function of time is

(A) A (B) B (C) C (D) D (E) E

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22. The work done by the tension force as the object moves to its lowest point is

(A) $mgL(1 - \cos\theta)$ (B) $mgL(1 - \sin\theta)$ (C) $mgL\cos\theta$ (D) $mgL\sin\theta$ (E) 0

23. A 2 kg mass moves in one dimension under the influence of a position-dependent force given by $F(x) = 2x - 8x^3$. The work done by this force as the object moves from $x = 2$ m to $x = 1$ m is closest to

(A) −6 J (B) −27 J (C) 6 J (D) 27 J (E) 8 J

24. A mass m falls from a height H onto a previously compressed spring. The mass rebounds with twice its incoming speed. If the spring and mass are in contact for a time T, the average power delivered to the mass by the spring is

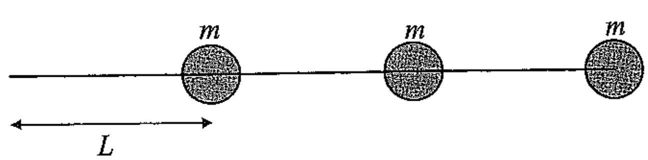
(A) $\frac{mgh}{T}$ (B) $\frac{2mgH}{T}$ (C) $\frac{\sqrt{2}mgH}{T}$ (D) $\frac{4mgH}{T}$ (E) $\frac{3mgH}{T}$

25. A mass m moving with speed v in the $+x$ direction collides head-on with a mass $4m$ moving with speed $\frac{1}{2}v$ in the $-x$ direction. If the two masses stick together, the velocity after collision is

(A) 0 (B) $\frac{1}{5}v$, $+x$ direction (C) $\frac{3}{5}v$, $+x$ direction
(D) $\frac{1}{5}v$, $-x$ direction (E) $\frac{3}{5}v$, $-x$ direction

26. A wheel with rotational inertia I is rotating with a constant angular velocity ω_0 when a torque is applied, slowing the wheel to $\frac{1}{2}\omega_0$ in a time T. The magnitude of the torque applied is

(A) $\frac{I\omega_0}{2T}$ (B) $\frac{I\omega_0}{T}$ (C) $\frac{3I\omega_0}{2T}$ (D) $\frac{2I\omega_0}{T}$ (E) $\frac{5I\omega_0}{2T}$



27. Three equal masses are connected at equal distances along a rod of length $3L$ and negligible mass. The moment of inertia about the left end of the rod is

(A) $3mL^2$ (B) $9mL^2$ (C) $14mL^2$ (D) $17mL^2$ (E) $27mL^2$

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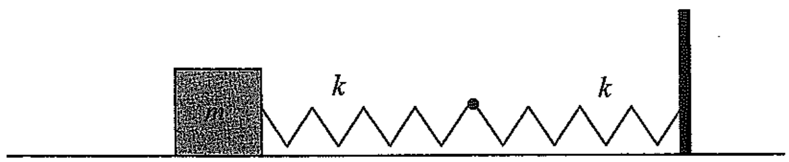
28. Planet X has an acceleration due to gravity at its surface that is 3 times that at Earth's surface. If the mass of X is twice the mass of the Earth, the radius of X in terms of R_e, the radius of Earth, is

(A) $\frac{2}{3}R_e$ (B) $\frac{3}{2}R_e$ (C) $\sqrt{\frac{2}{3}}R_e$ (D) $\sqrt{\frac{3}{2}}R_e$ (E) $\frac{2}{\sqrt{3}}R_e$



29. Two identical springs with spring constant k are connected as shown in the figure, and a mass m is attached. When the mass is displaced from equilibrium, the period of oscillation is

(A) $2\pi\sqrt{\frac{m}{k}}$ (B) $2\pi\sqrt{\frac{m}{2k}}$ (C) $2\pi\sqrt{\frac{2m}{k}}$ (D) $4\pi\sqrt{\frac{m}{k}}$ (E) $2\sqrt{2}\pi\sqrt{\frac{m}{k}}$

30. The position of a 3-kg mass moving in one dimension is given in meters as a function of time by the following equation: $x(t) = t^3 - 4t^2 + 7$. At $t = 1$ s, the force on the object is

(A) 12 N (B) 15 N (C) 36 N (D) −6 N (E) −2 N

31. A toy air gun can fire a dart to a height H when fired straight up. What is the maximum height that the projectile will reach if it's fired at an angle of 60° with the vertical?

(A) $\frac{\sqrt{3}}{2}H$ (B) $\frac{3}{4}H$ (C) $\frac{1}{2}H$ (D) $\frac{1}{4}H$ (E) $\frac{1}{3}H$

32. A 40-kg child and an 80-kg man are ice skating in tandem, with the child in front of the man. When they're moving at 10 m/s, the man pushes the child so that she moves at 15 m/s relative to the ice. After she separates, what will be the velocity of their center of mass?

(A) 7.5 m/s (B) 9 m/s (C) 10 m/s (D) 12.5 m/s (E) 15 m/s

33. A circular hoop of mass M and radius R rolls down an incline without slipping, from an initial height H. The translational kinetic energy at the bottom of the incline is

(A) mgH (B) $\frac{1}{2}mgH$ (C) $\frac{1}{3}mgH$ (D) $\frac{2}{3}mgH$ (E) $\frac{1}{4}mgH$

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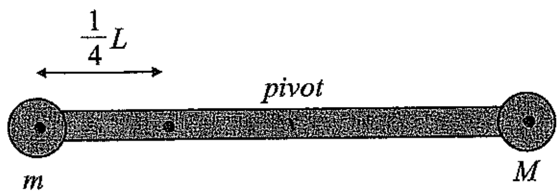
34. A block slides down a rough incline, experiencing a constant force of friction. At the bottom of the incline, it encounters an uncompressed, massless spring and eventually rebounds back up the incline. After the mass has reached its highest point on the rebound, which of the following is true for the work done by gravity and the work done by the spring force?

	Gravity	Spring
(A)	positive	0
(B)	negative	0
(C)	0	positive
(D)	negative	positive
(E)	0	0



35. A stick of mass m and length L has its mass distributed nonuniformly so that its center of mass is $\frac{1}{4}L$ from the left. A mass m is attached to the left end of the stick. What mass M must be attached to the right end of the stick so that the system won't rotate when it's pivoted about the geometrical center of the stick?

(A) $\frac{1}{2}m$ (B) m (C) $\frac{3}{2}m$ (D) $2m$ (E) $\frac{5}{2}m$

STOP
END OF SECTION I, MECHANICS

IF YOU FINISH BEFORE TIME IS CALLED, YOU MAY CHECK YOUR WORK ON SECTION I, MECHANICS ONLY.

DO NOT TURN TO ANY OTHER TEST MATERIALS.

STOP

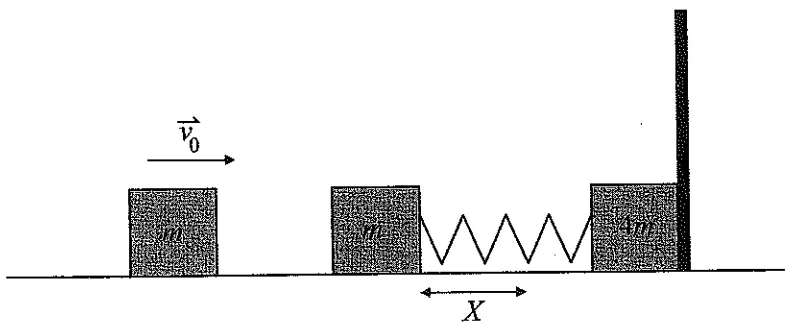
AP PHYSICS C TEST

SECTION II—MECHANICS

Time: 45 minutes

3 Questions

Directions: Answer all 3 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.



1. Two masses m and $4m$ are connected by a spring on a smooth horizontal surface. The larger mass is currently in contact with a barrier that will not move, and a third mass m moving with speed v_0 slides across the surface and strikes the smaller mass as shown in the figure. Upon impact, the two equal masses stick together, and the spring compresses a maximum X. Answer the following in terms of m, v_0, and X.

   (a) Determine the speed of the smaller masses immediately after impact.
   (b) Determine the force constant of the spring.
   (c) How much mechanical energy is lost as a result of the collision?

   The barrier is now removed so that the larger mass is free to move on the surface, and the collision is repeated. The same initial conditions are reproduced so that one of the smaller masses moving with speed v_0 collides with the other, sticking to it.

   (d) When the spring is at maximum compression, what will be the speed of each mass?
   (e) Determine the new maximum compression of the spring.

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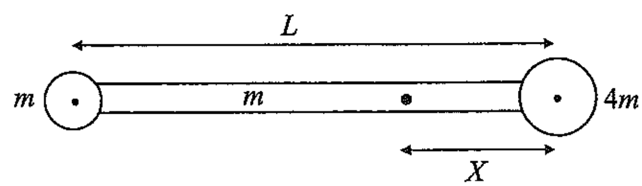
2. A tall glass cylinder contains a clear liquid. When a small spherical mass m is gently placed into the liquid, it experiences a resistive force $\overline{F} = -bmv$ proportional to the velocity of the mass as it falls. b is a constant that depends on properties of the liquid.
   (a) What is the initial acceleration of the mass just as it is released?
   (b) Determine the terminal speed of the mass under the conditions described.
   (c) Write the differential equation that could be used to find the velocity of the mass at any time $t > 0$.
   (d) Determine the time it takes for the mass to reach $\frac{1}{2}$ its terminal speed.
   (e) You are given a supply of several different clear liquids. Describe an experimental procedure for determining the b-values for these liquids. You may use the apparatus described earlier and any of the following.

meter stick	stopwatch	set of known masses
roll of string	spring	



3. Two masses m and $4m$ are connected by light pins to the ends of a stick of mass m and length L. The stick is pivoted to rotate vertically about a horizontal axis at the center of mass of the system, located a distance X from the larger mass.
   (a) Determine the value of X in terms of m and L.
   (b) What is the moment of inertia of the system about its center of mass? The moment of inertia of a uniform stick of mass m and length L about is center is $\frac{1}{12}mL^2$.

   With the system initially at rest and the stick horizontal, another mass m is dropped onto the smaller mass. Just before it strikes the mass, it is moving *down* with speed v, and just after the collision, it is moving *up* with speed $\frac{v}{3}$.
   (c) Describe the motion of the pivoted system after the collision.
   (d) Find the angular speed of the stick after the collision.
   (e) Find the force exerted on the larger mass by its connecting pin when this mass is at its lowest position.

STOP
END OF SECTION II, MECHANICS

IF YOU FINISH BEFORE TIME IS CALLED, YOU MAY CHECK YOUR WORK ON SECTION II, MECHANICS ONLY.

DO NOT TURN TO ANY OTHER TEST MATERIALS.

STOP