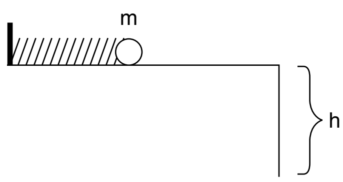
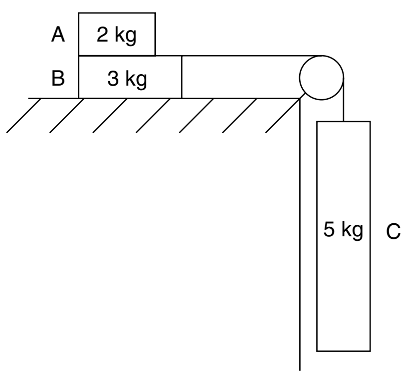


31. A ball of mass m is launched from a horizontal table of height h by a spring having a spring constant k. After the ball leaves the spring, it hits the floor after a time of

(A) $\sqrt{2h/g}$
(B) $\frac{2h}{\sqrt{g}}$
(C) $\sqrt{gh}$
(D) $\frac{h}{\sqrt{g}}$
(E) $\sqrt{2gh}$

Questions 32–33 refer to the following figure.



A 2 kg mass A is placed and secured atop a 3 kg mass B. Both rest on a horizontal surface having a coefficient of friction 0.6 with the bottom of the masses. A mass of 5 kg hangs by a cord attached to a frictionless pulley as shown.

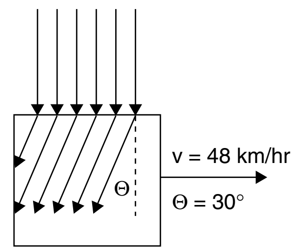
32. The acceleration of the 3 kg mass is most nearly

(A) 1 m/s^2
(B) 2 m/s^2
(C) 3 m/s^2
(D) 4 m/s^2
(E) 5 m/s^2

33. Block A is removed and the experiment is repeated. The acceleration of the 5 kg mass is now

(A) 1 m/s^2
(B) 2 m/s^2
(C) 3 m/s^2
(D) 4 m/s^2
(E) 5 m/s^2

Questions 34–35 refer to the following figure.



Falling raindrops make an angle of 30° with the vertical when they hit the side window of a car traveling at a constant speed of 48 km/hr.

34. The vertical speed of the raindrops hitting the window is nearest to

(A) $\frac{9}{\sqrt{3}}$ m/s
(B) $\frac{13}{\sqrt{3}}$ m/s
(C) $\frac{24}{\sqrt{3}}$ m/s
(D) $\frac{29}{\sqrt{3}}$ m/s
(E) $\frac{40}{\sqrt{3}}$ m/s

35. Two equal masses oscillate vertically on two different springs with differing values for k. The spring of lesser spring constant has the

(A) larger oscillation frequency.
(B) smaller oscillation amplitude.
(C) larger oscillation amplitude.
(D) shorter oscillation period.
(E) larger oscillation period.

END OF SECTION I, MECHANICS. IF YOU FINISH BEFORE TIME IS CALLED, YOU MAY CHECK YOUR WORK ON THIS SECTION ONLY. DO NOT TURN TO ANY OTHER TEST MATERIALS.

STOP

CliffsAP Physics C Practice Exam 2

Sample C Exam #2 Answers and Comments

Mechanics

Multiple Choice

1. **(D)** $\mathbf{a} = \frac{d\mathbf{v}}{dt} = 14t$

   Taking the antiderivative: $\int 14t\,dt = (14)\left(\frac{1}{2}\right)(t^2) = 7\,t^2$ (This is the velocity.)

   Taking the antiderivative of the velocity to get the displacement:

   $$\int 7t^2\,dt = (7)\left(\frac{1}{3}\right)(t^2) = \left(\frac{7}{3}\right)t^3$$

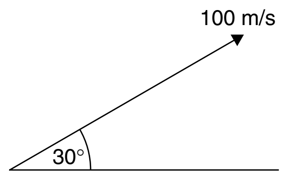
   Substituting 3 seconds for t results in the displacement of **63 m.**

2. **(C)** $\sin 30° = \frac{\mathbf{v}_{\mathbf{O\ VERTICAL}}}{100\text{ m/s}}$

   $$\mathbf{v}_{\mathbf{O\ VERTICAL}} = 50\text{ m/s}$$

   Using $\mathbf{v_F}^2 = \mathbf{v_O}^2 + \mathbf{2ad}$, $(50\text{ m/s})^2 = 0 + (2)(10\text{ m/s}^2)(\mathbf{h})$

   $$\mathbf{h = 125\ m}$$



3. **(B)** Using $\mathbf{T = 2\pi(1 / g)^{\frac{1}{2}}}$,

   $$T = \mathbf{2\pi(s / g)^{\frac{1}{2}}}$$

4. **(C)** For any object in a circular orbit around a planet, its weight equals the centripetal force exerted on it by the planet. $\mathbf{F} = m\mathbf{g} = \frac{m\mathbf{v}^2}{r}$ and $m\mathbf{g_D} = \frac{m\mathbf{v_D}^2}{D}$

   Since $\mathbf{a} = \frac{\mathbf{F}}{m}$, for gravitational acceleration: $\mathbf{g} = \frac{GM_E}{D^2}$

   $\frac{GM_E}{D^2} = \frac{\mathbf{v_D}^2}{D}$ can now be used in a ratio for D to 2D:

   $$\frac{GM_E / D = \mathbf{v_D}^2}{GM_E / 2D = \mathbf{v_{2D}}^2} \text{ yields } \mathbf{v_D}^2 = \frac{\mathbf{v_{2D}}^2}{(2)^{\frac{1}{2}}}$$

5. **(D)** Using $\mathbf{\Sigma m v_O = \Sigma m_{FINAL} v_{FINAL}}$,

   $$(3\text{ kg})(2\text{ m/s E}) + 0 = (8\text{ kg})(\mathbf{v_{FINAL}})$$
   $$v_{FINAL} = 6/8\text{ m/s or } \mathbf{0.75\ m/s}$$

6. **(C)** The kinetic energy of the blocks is completely transferred to the spring at the point where the system stops. $\mathbf{E_K = E_{P\ SPRING}}$

   $$\left(\frac{1}{2}\right)m\mathbf{v}^2 = \left(\frac{1}{2}\right)k\mathbf{x^2}$$
   $$\mathbf{x} = (m\mathbf{v^2}/k)^{\frac{1}{2}} = [(8\text{ kg})(0.75\text{ m/s})^2 / 8\text{ N / m})]^{\frac{1}{2}} = \mathbf{0.75\ m}$$

7. **(A)** The total kinetic energy of the disk will be completely transformed into gravitational potential when it comes to a momentary stop up the incline.

$$\mathbf{E_{K\ ROTATIONAL} + E_{K\ LINEAR} = E_{P\ GRAVITATIONAL}}$$
$$\left(\frac{1}{2}\right)(\mathrm{I})(\boldsymbol{\omega}^2) + \left(\frac{1}{2}\right)\mathrm{m}\mathbf{v}^2 = \mathrm{m}\mathbf{gh}$$
$$\left(\frac{1}{2}\right)\left(\frac{1}{2}\right)(\mathrm{mr}^2)\ (\boldsymbol{\omega}^2) + \left(\frac{1}{2}\right)\mathrm{m}\mathbf{v}^2 = \mathrm{m}\mathbf{gh}$$
$$\left(\frac{1}{4}\right)\mathbf{v}^2 + \left(\frac{1}{2}\right)\mathbf{v}^2 = \mathbf{gh}$$
$$\mathbf{h = \frac{3v^2}{4g}}$$

8. **(E)** The planet's angular momentum remains constant at all points in its orbit because although its linear speed may change, its angular speed does not. As the planet moves away from the Sun, its linear speed decreases due to decreased gravitational attraction.

9. **(D)** Since $\mathbf{F(x) = -\frac{dU(x)}{dx}}$,

$$-\mathrm{dU}(\mathbf{x}) = \mathbf{F(x)}\mathrm{d}\mathbf{x}$$
$$\int -\mathrm{dU}(\mathbf{x}) = \int \mathbf{F(x)}\mathrm{d}\mathbf{x}$$
$$-\mathrm{U}(\mathbf{x}) = \int (20\mathbf{x} - 8\mathbf{x}^2\ \mathrm{d}\mathbf{x})$$
$$\mathrm{U(3m)} = -(90 - 72)\ \mathrm{J} = -18\ \mathrm{J}\ \text{or a stretched difference of 18 J}$$

10. **(D)** At point P, the apex of its trajectory, the projectile has only horizontal velocity and, "since gravity is never turned off," the particle's acceleration is toward the earth.

11. **(A)** The force applied directly to the block equals the force applied to the rope **F minus** the force needed to accelerate the rope of mass m. This results in

$\mathbf{F_{BLOCK} = F - ma}$

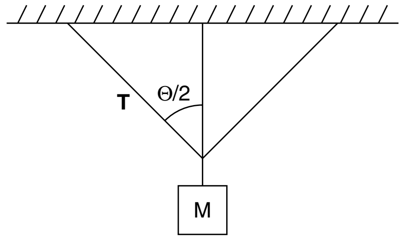
12. **(B)** At the maximum speed at the top of the bump, the car's weight would equal the centripetal force. $\mathrm{m}\mathbf{g} = \frac{\mathrm{m}\mathbf{v}^2}{\mathrm{r}}$

$$\mathbf{v = (gr)^{\frac{1}{2}}} = [(10\ \mathrm{m/s^2})(0.5\ \mathrm{m})]^{\frac{1}{2}} = \mathbf{5^{\frac{1}{2}}\ m/s\ (closest\ to\ 2\ m/s)}$$

13. **(E)** By the Law of Conservation of Momentum, both linear and angular momentum are always conserved. This means that in the absence of any outside applied force or torque, the total momentum does not change. Since $E_{K\ ROTATIONAL} = \left(\frac{1}{2}\right)\mathbf{I}\boldsymbol{\omega}^2$, changing the mass distribution by changing arm position only changes I, which in turn changes the angular velocity $\boldsymbol{\omega}$.

14. **(A)** $\cos \Theta/2 = \frac{\mathrm{Mg}/2}{\mathbf{T}}$

$$\mathbf{T} = \frac{\mathrm{Mg}}{2\cos\Theta/2}$$



24. **(B)** Using ($\mathbf{F_{NET}} = \mathbf{F_{WT\ 4KG}} - \mathbf{F_F}$)

$$= (4\text{ kg})(10\text{ m/s}^2) - \mu\mathbf{F_N}$$
$$= (40\text{ N}) - (0.3)(3\text{ kg})(10\text{ m/s}^2) = 40\text{ N} - 9\text{ N} = 31\text{ N of net force}$$

Now using $\mathbf{F_{NET} = ma}$ to find the acceleration of the system, $\mathbf{a} = \mathbf{F_{NET} / m}$. (Here, m is the sum of the masses in the system.)

$$\mathbf{a} = (31\text{ N}) / (3\text{ kg} + 4\text{ kg}) = 4.4\text{ m/s}^2\text{ (closest to 4.5 m/s}^2)$$

25. **(B)** The net force on M1 is what causes it to accelerate:

$$\mathbf{F_{NET}} = M_1\mathbf{a_1} = (3\text{ kg})(4.4\text{ m/s}^2) = 13.2\text{ N}$$

26. **(B)** Doubling the friction coefficient to 0.6 means that the frictional force is doubled:

$$\mathbf{F_{NET} = F_{WT\ M2} - F_{F\ M1}} = 40\text{ N} - (0.6)(3\text{ kg})(10\text{ m/s}^2) = 40\text{ N} - 18\text{ N} = 22\text{ N}$$

Now calculating the new acceleration:

$$\mathbf{a = F_{NET} / m_{TOT}} = 22\text{ N} / 7\text{ kg} = 3.1\text{ m/s}^2\text{ (closest is 3 m/s}^2)$$

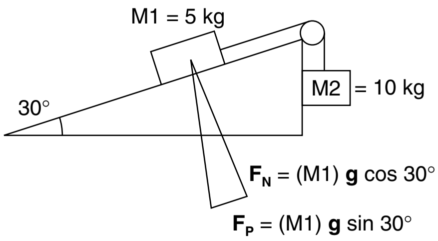
27. **(C)** Using CW and CCW torques: (let x be the distance from the 8 kg mass)

$$\text{CCW torque} = \text{CW torque}$$
$$(2.5\text{kg})(10\text{ m/s}^2)(100\text{ cm} - x) = (4\text{ kg})(10\text{ m/s}^2)(x)$$

x = 38 cm, position C

28. **(E)** The net force on the system is the weight of the 10 kg mass MINUS the parallel force of the 5 kg mass. $\mathbf{F_{NET}} = (M2)(\mathbf{g}) - \mathbf{F_{P\ M1}}$

$$= (10\text{ kg})(10\text{ m/s}^2) - (5\text{ kg})(10\text{ m/s}^2)(\sin 30°)$$
$$= 100\text{ N} - 25\text{ N} = \mathbf{75\text{ N}}$$



29. **(B)** Using $\mathbf{F_{NET} = ma}$,

$$\mathbf{a} = \frac{\mathbf{F_{NET}}}{m_{TOTAL}}\text{ (Both masses will accelerate at the same rate.)}$$
$$\mathbf{a} = (75\text{ N}) / (15\text{ kg}) = 5\text{ m / s}^2$$

30. **(C)** Again, using $\mathbf{F_{NET} = ma}$,

$$\mathbf{a} = \frac{\mathbf{F_{NET}}}{m_{TOTAL}}\text{ (Both masses will accelerate at the same rate.)}$$
$$\mathbf{a} = \frac{(10\text{ kg})(10\text{ m/s}^2) - (10\text{ kg})(10\text{ m/s}^2)(\sin 30°)}{20\text{ kg}}$$
$$= 50\text{ N} / 20\text{ N} = 2.5\text{ m / s}^2$$

31. **(A)** Using $\mathbf{d_{VERT} = (v_{O\ VERT})(t) + \left(\frac{1}{2}\right)at^2}$,

$$\mathbf{h} = (0) + (\mathbf{g}/2)(t^2) \text{ and } \mathbf{t = (2h / g)^{\frac{1}{2}}}$$

32. **(B)** First, finding the net force on the system:

$$\begin{aligned} \mathbf{F_{NET}} &= m\mathbf{g}_{5\,kg} - \mathbf{F}_{F\,2+3\,kg} \\ &= (5\text{ kg})(10\text{ m/s}^2) - \mu\mathbf{F}_{N\,2+3\,kg} \\ &= (50\text{ N}) - (0.6)(5\text{ kg})(10\text{ m/s}^2) \\ &= 20\text{ N} \end{aligned}$$

Using $\mathbf{F_{NET} = ma}$, (The entire system will be accelerated together.)

$$\mathbf{a} = \frac{\mathbf{F_{NET}}}{m} = \frac{20\text{ N}}{10\text{ kg}} = 2\text{ m/s}^2$$

33. **(D)** $\mathbf{F_{NET}} = m\mathbf{g}_{5\,kg} - \mathbf{F}_{F\,3\,kg}$

$$= (50\text{ N}) - (0.6)(3\text{ kg})(10\text{ m/s}^2) = 32\text{ N}$$

Using $\mathbf{F_{NET} = ma}$, (The entire system will be accelerated together.)

$$\mathbf{a} = \frac{\mathbf{F_{NET}}}{m} = \frac{32\text{ N}}{8\text{ kg}} = 4\text{ m/s}^2$$

34. **(E)** $\tan 30° = \frac{48\text{ km/hr}}{\mathbf{v_{VERT}}}$

$$\mathbf{v_{VERT}} = \frac{(48\text{ km/hr})}{\left(3^{\frac{1}{2}}\big/3\right)}\frac{(1\text{ hr})}{(3600\text{ sec})}\frac{(1000\text{ m})}{(\text{km})} = \frac{40}{(3)^{\frac{1}{2}}} \text{ or } \frac{40}{\sqrt{\mathbf{3}}}$$

35. **(E)** A smaller spring constant means that the spring exerts less force per stretch or compression distance than one of greater k. This translates into fewer Newtons of force per meter of stretch or compression. The result is a spring being "looser" or less stiff, which allows for a longer oscillation period.

Electricity and Magnetism

Multiple Choice

36. **(D)** Since the **series** combination of 3 Ω resistors is in series with the parallel 3 Ω resistors, the equivalent resistance of the circuit equals 9 Ω + the parallel resistors:

$$\frac{1}{R_{2,3}} = \frac{1}{3\,\Omega} + \frac{1}{3\,\Omega} = \frac{2}{3\,\Omega} \text{ and } R_{2,3} = 1.5\,\Omega$$

The equivalent resistance of the circuit = (9 + 1.5) Ω = 10.5 Ω

37. **(A)** Using **V = IR**,

$$I = V/R = (12\text{ V}) / (10.5\,\Omega) = 1.1\text{ A}$$

38. **(C)** The current of about 1 A splits evenly to both R_2 and R_3, which both receive about 0.5 A. Therefore, the voltmeter reads:

$$\mathbf{V} = IR = (0.5\text{ A})(3\,\Omega) = \text{about } 1.5\text{ V}$$

(d) First, find the total height of the ball:

$$\mathbf{y} = (0.6)(\cos 20°) = 0.56\,\text{m}$$

The table's height = 0.7 m.

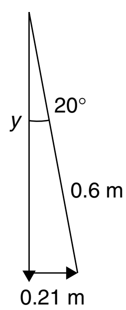
The ball rises 0.6 m – 0.56 m = 0.04 m

The total height of the ball = 0.7 + 0.04 m = 0.74 m

Find the time the ball is in the air:

Using $\mathbf{d} = \mathbf{v_O}t + \left(\frac{1}{2}\right)\mathbf{a}t^2$

$$-0.74\text{ m} = -4.9\text{ m/s}^2\,(t^2)$$
$$t = 0.39\text{ sec in the air}$$



To find the velocity of the ball horizontally from the force of the fan:

$$\mathbf{F}\Delta t = M\Delta\mathbf{v}$$
$$(0.54\text{ N})(0.39\text{ sec}) = (0.15\text{ kg})(\Delta v)\text{ yields } v_H = 1.4\text{ m/s}$$

Using $\mathbf{d} = \mathbf{v_O}t + \left(\frac{1}{2}\right)\mathbf{a}t^2$ (for the horizontal distance traveled)

$$\mathbf{d}_H = (1.4\text{ m/s})(0.39\text{ sec}) + 0 = 0.55\text{ m}$$

(e) First, for the final horizontal velocity:

$$= 1.4\text{ m/s} = \mathbf{v_F}\text{ horizontally.}$$

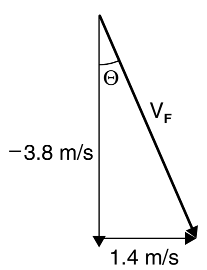
For the final vertical velocity: Using $\mathbf{v_F^2 = v_O^2 + 2ad}$:

$$\mathbf{v_F^2} = 0 + (2)(-9.8\text{ m/s}^2)(-0.74\text{ m})\text{ and }\mathbf{v_F} = -3.8\text{ m/s vertically}$$

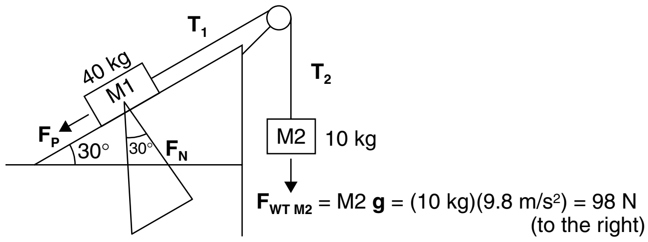
The ball lands with a final speed of $[(1.4\text{ m/s})^2 + (-3.8\text{ m/s})^2]^{\frac{1}{2}} = 4.0$ m/s.

$$\Theta\text{: } \tan\Theta = \left|\frac{1.4}{3.8}\right| = 0.368\text{ and } \Theta = 20°$$

The ball lands with a speed of 4.0 m/s at an angle of 20° with the vertical.



Mech. 2. **(a)** Acceleration is due to the net force acting on the sum of the masses. The net force is the difference between the **PARALLEL FORCE** pulling the M1 block **DOWN THE RAMP (to the left)** and the **WEIGHT** of the M2 block pulling the system **to the right.**



$$\mathbf{F_{P\,M1} = (M1)\,g\,\sin 30°}$$
$$= (40\text{ kg})(9.8\text{ m/s}^2)(0.5)$$
$$= 196\text{ N } \textbf{(to the left)}$$

The NET FORCE is 196 N – 98 N = 98 N **to the left**

Using $\mathbf{F_{NET} = ma}$,

$$\mathbf{a} = \frac{\mathbf{F_{NET}}}{m} = \frac{(98\text{ N})}{(40+10)\text{ kg}} \text{ to the left} = \mathbf{1.96\ m/s^2 \text{ or } 2.0\ m/s^2} \textbf{ to the left or DOWN THE INCLINE}$$

(b) The tension in the string is the weight plus the accelerating force on M2:

$$\mathbf{T} = (10\text{ kg})(9.8\text{ m/s}^2) + (10\text{ kg})(2.0\text{ m/s}^2) = 98\text{N} + 20\text{N} = 118\text{ N} \approx 120\text{ N}$$

(c) Adding friction to the incline adds a force that retards any motion. Already, there are forces of 196 N **to the left** and 98 N **to the right.** Finding the frictional force: Using $\mu = \mathbf{F_F / F_N}$,

$$\mathbf{F_F} = \mu\,\mathbf{F_N} = (0.25)(40\text{ kg})(9.8\text{ m/s}^2)(\cos 30°) = 85\text{ N}$$

This opposes motion down the incline. The net force now becomes

$$\mathbf{F_{NET} = F_{P\,M1} - (F_{WT\,M2} + F_F)}$$

$$\mathbf{= 196\ N - 98\ N - 85\ N = 13\ N} \textbf{ to the left}$$

The new acceleration of the system becomes

$$\mathbf{a} = \frac{\mathbf{F_{NET}}}{m} = \frac{(13\text{ N})}{(40+10)\text{ kg}} \text{ to the left} = \mathbf{0.26\ m/s^2} \textbf{ to the left or DOWN THE INCLINE}$$

(d) i. $\mathbf{F_P} = (10\text{ kg})(9.8\text{ m/s}^2)(\sin 30°) = 49\text{ N}$ **(to the left)**

$$\mathbf{F_{WT\,M2} = M2\ g} = (40\text{ kg})(9.8\text{ m/s}^2) = 392\text{ N } \textbf{(to the right)}$$
$$\mathbf{a} = \frac{\mathbf{F_{NET}}}{m} = \frac{(392-49)\text{ N}}{50\text{ kg}} = \mathbf{6.9\ m/s^2} \textbf{ to the right.}$$

ii. $\mathbf{T_1} = \mathbf{T_2} = 40\text{ kg }(\mathbf{g} - \mathbf{a}) = 40\text{ kg }(9.8\text{ m/s}^2 - 6.9\text{ m/s}^2)$

$$= 40\text{ kg }(2.9\text{ m/s}^2)$$
$$= 116\text{ N}$$

iii. $\mathbf{F_F} = \mu\,\mathbf{F_N} = (0.25)(10\text{ kg})(9.8\text{ m/s}^2)(\cos 30°) = 21\text{ N}$

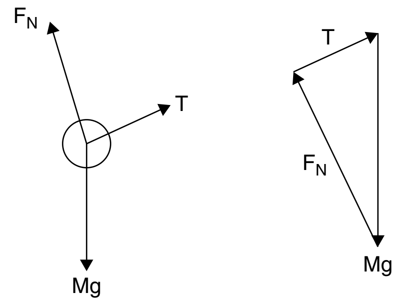
$$\mathbf{F_P\ 10\ KG} = (10\text{ kg})\ \mathbf{g}\sin 30° = 49\text{ N } \textbf{to the left}$$
$$\mathbf{F_{WT}\ 40\ KG} = (40\text{ kg})(9.8\text{ m/s}^2) = 392\text{ N } \textbf{to the right}$$

Since the much larger force is now to the right, friction acts to the left:

$$\mathbf{F_{NET} = 392\ N - 49\ N - 21\ N = 322\ N\ to\ the\ right}$$

The new acceleration of the system becomes $\mathbf{a} = \frac{F_{NET}}{m} = \frac{(322\,N)}{(50)\,kg}$ to the right = **6.4 m/s² to the right**

Mech. 3. **(a)**



(b) $\mathbf{T = F_P = Mg\sin\Theta}$

(c) The kinetic energy the sphere has at the bottom of the incline must be equal to the potential energy it had at the top.

$$\mathbf{E_{K\ TOTAL} = E_P}$$

$$\mathbf{E_{K\ LINEAR} + E_{K\ ROTATIONAL} = E_P}$$

$$\left(\frac{1}{2}\right)\mathbf{Mv^2} + \left(\frac{1}{2}\right)\mathbf{I\omega^2 = Mgh}$$

$$\left(\frac{1}{2}\right)M\mathbf{v}^2 + \left(\frac{1}{2}\right)\left(\frac{2}{5}\right)(Mr^2)\boldsymbol{\omega}^2 = M\mathbf{g}h$$

$$\frac{v^2}{2} + \frac{r^2}{5}(\mathbf{v}/r)^2 = \mathbf{g}h$$

$$\left(\frac{7}{10}\right)\mathbf{v}^2 = \mathbf{g}h \text{ and } \mathbf{v} = (\mathbf{10\ gh / 7})^{\frac{1}{2}}$$

(d) Using $\mathbf{V_f^2 = V_o^2 + 2ad}$:

$$\frac{10}{7}gh = 2(a)(d)$$

The sphere's linear acceleration is $\mathbf{a_{LINEAR}} = \frac{5}{7}\,\mathbf{g}h/d$ and $d = h/\sin\Theta$

$$\mathbf{a_{LINEAR}} = \frac{5}{7}\,g\sin\Theta$$

Since $\boldsymbol{\alpha} = \frac{\mathbf{a}}{r}$, $\boldsymbol{\alpha} = \frac{5\mathbf{g}\sin\Theta}{7\,r}$

(e) Using $\mathbf{d = v_Ot} + \left(\frac{1}{2}\right)\mathbf{at^2}$,

$$\mathbf{d} = \left(\frac{1}{2}\right)(\mathbf{a})(t^2)$$

$$t = (2\mathbf{d/a})^{\frac{1}{2}} = \left(\frac{2\mathbf{d}}{\frac{5}{7}\mathbf{g}\sin\Theta}\right)^{\frac{1}{2}}$$

$$= \left(\frac{14\mathbf{d}}{5\,\mathbf{g}\sin\Theta}\right)^{\frac{1}{2}}$$