Answer Key for AP Physics 1 Practice Exam, Section I

Question 1: B	Question 21: C
Question 2: A	Question 22: ~~A~~ C
Question 3: C	Question 23: ~~C~~ A
Question 4: B	Question 24: ~~C~~ A
Question 5: D	Question 25: ~~B~~ C
Question 6: A	Question 26: D
Question 7: C	Question 27: ~~A~~ D
Question 8: C	Question 28: ~~B~~ A
Question 9: C	Question 29: ~~A~~ D
Question 10: B	Question 30: D
Question 11: C	Question 31: B
Question 12: D	Question 32: D
Question 13: D	Question 33: C
Question 14: B	Question 34: A
Question 15: D	Question 35: B
Question 16: D	Question 36: ~~C~~ B
Question 17: ~~C~~ A	Question 37: ~~A, B~~ D
Question 18: B	Question 38: C, D
Question 19: B	Question 39: B, D
Question 20: ~~C~~ B	Question 40: A, B

How to score

Step 1:
MC × 1.45 = ☐ ①

Step 2:
FRQ's = ☐ ②

Step 3:
☐ ① + ☐ ② = ☐ ③

Step 4:
☐ ③ / 116 × 100 = Raw %

Cutoffs:
5 – 70%
4 – 54%
3 – 40%
2 – 25%

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Question 1

7 points total | **Distribution of points**

(a) 3 points

For using an equation expressing the conservation of energy — 1 point

$mgh = 2mgR + \frac{1}{2}mv_{top}^2$ or $mgh = (1/2)mv_1^2$ or $mgh = (1/2)mv^2$

For using two forms of energy when block B is at the top of the loop or using the initial kinetic energy — 1 point

For expressing the correct answer in terms of the listed quantities — 1 point

$$h = \frac{2mgR + \frac{1}{2}mv_{top}^2}{mg}$$

$$h = 2R + \frac{v_{top}^2}{2g}$$

(b) 2 points

For a correct answer "Greater than $2h$" with an explanation — 1 point

No point is earned for a correct selection without an explanation.

If an incorrect answer is selected, the following point for using conservation of energy can still be earned.

For using an equation or semi-quantitative reasoning expressing the conservation of energy Note: "semi-quantitative reasoning" here includes reasoning in terms of proportionality, squared relationships, etc. — 1 point

$$mgh = \frac{1}{2}mv_1^2$$

$$h = \frac{v_1^2}{2g}$$

Question 1 (continued)

Distribution of points

(c) 2 points

Correct answer: $v_C = \frac{3}{2} v_A$.

Note: there is no "answer point", so no credit is awarded for an answer with no work shown

For using momentum conservation to relate the speeds before and after the completely inelastic collision between blocks B and C — 1 point

$2mv_C = (2m + m)v_{BC} = 3mv_{BC}$, where v_{BC} is the speed of blocks B and C after the collision

$2v_C = 3v_{BC}$

For setting the speed of blocks B and C after the collision equal to the speed of block B after its elastic collision with block A, in order for blocks B and C to make it over the bump. — 1 point

$2v_C = 3v_A$

$v_C = \frac{3}{2} v_A$

[redacted]

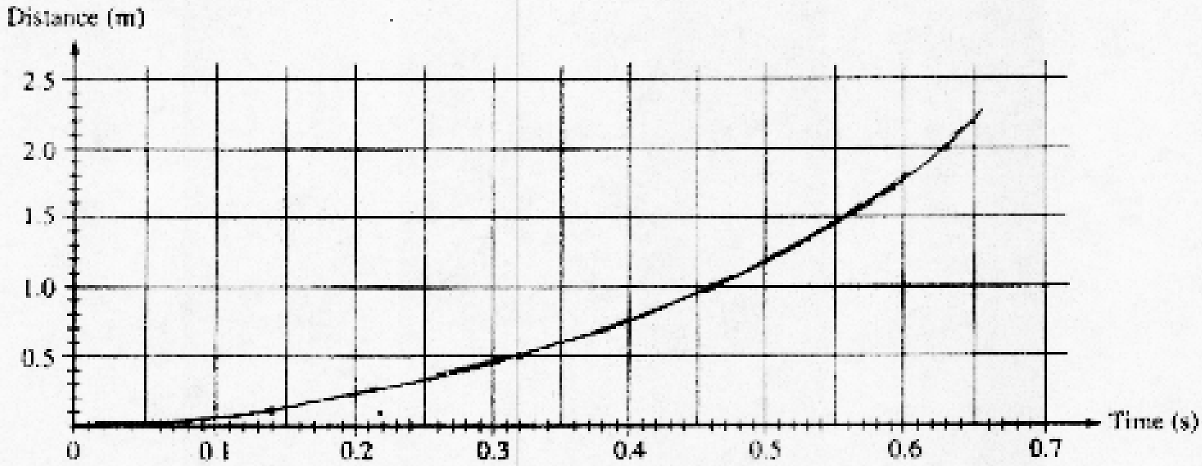
AP1 Practice Exam [redacted] Key 1

[redacted]

Question 2

15 points total | **Distribution of points**

(a) 3 points



For a line that is close to all of the data points — 1 point

For a smooth curve — 1 point

For a nonlinear curve that is concave up — 1 point

(b) 2 points

Distance and time are related by the equation $D = \frac{1}{2}at^2$

For a correct pair of quantities, expressed in terms of D and t, that will yield a straight line — 2 points

Examples: D and t^2 OR $\sqrt{D}$ and t

Question [redacted] (continued)

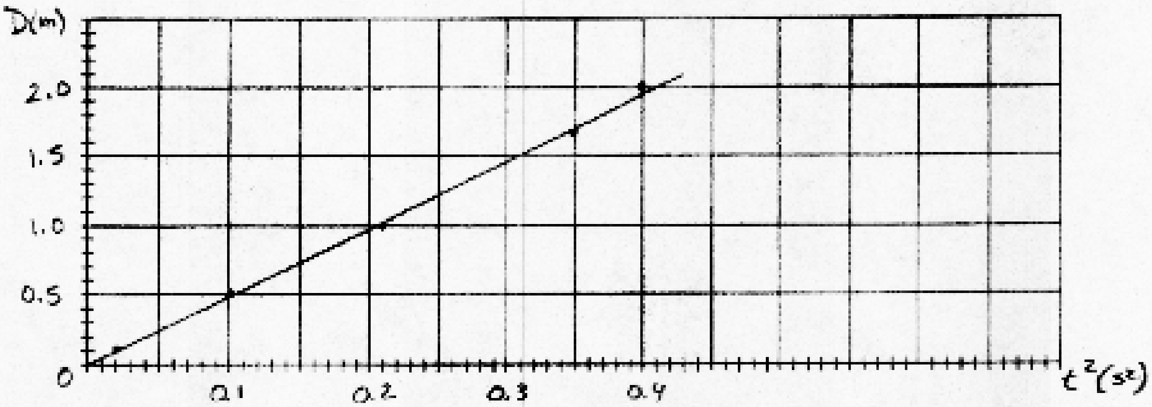
2

Distribution of points

(c) 4 points

For correctly scaling and labeling the horizontal axis for a quantity cited in part (b)	1 point
For correctly scaling and labeling the vertical axis for a quantity cited in part (b)	1 point
For a reasonably correct plotting of the data	1 point
For a reasonably straight line through the data points	1 point

Example graphing D versus t^2:



Note: If part (b) contains incorrect variables and they are correctly graphed in part (c), a maximum of 2 points could be earned.

(d) 3 points

For determining the slope of the line drawn on the graph — 1 point

Using the example graph above, $\text{slope} = \dfrac{(2.0 - 0.1)\text{ m}}{(0.41 - 0.02)\text{ s}^2} = \dfrac{1.9\text{ m}}{0.39\text{ s}^2} = 4.9\text{ m/s}^2$

For an expression relating g to the slope — 1 point

In the example given, $D = \dfrac{1}{2}gt^2$, so $\dfrac{1}{2}g = \text{slope}$

For a value of g in the range 9-11 m/s^2 — 1 point

In the example given, $g = 2(4.9\text{ m/s}^2) = 9.8\text{ m/s}^2$

(e) 3 points

For a good, specific improvement	2 points
For an explanation of how this would improve accuracy	1 point

Example: Do several trials for each value of D and take averages. This reduces personal and random error.

One point could be earned for less appropriate or less specific answers, for example "do trials in a vacuum" or "cut down on air resistance."

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Question 3

12 points total | **Distribution of points**

(a)

i. 2 points

For recognizing a small horizontal velocity for the block at point P — 1 point

For stating or implying that the block doesn't go very far even though there is a longer fall time — 1 point

Example: Even though the large h_2 allows the block to stay in the air for a long time, the small h_1 means the system loses little gravitational potential energy and hence gains little kinetic energy so that it leaves the table with too little speed to cover much distance while aloft.

ii. 2 points

For recognizing a large horizontal velocity for the block at point P — 1 point

For mentioning a short time of flight for the falling block — 1 point

Example: Now the block gains a lot of kinetic energy on the ramp so that it leaves the table with a large horizontal speed. But the small h_2 means the block spends so little time in the air that it lands before covering much horizontal distance.

(b) 3 points

For using an energy conservation statement (corresponds to step 1 in example below) — 1 point

For setting up a time of flight calculation using vertical acceleration (corresponds to step 2a in example below) — 1 point

Note: derivation of t must be shown to earn credit.

For using $vt = d$ to determine distance traveled (corresponds to step 2b in example below) — 1 point

Example:

Step 1: Use energy conservation to find the block's speed at the bottom of ramp, which equals the launch speed v_1 at point P.

$$mgh_1 = \frac{1}{2}mv_1^2 \Rightarrow v_1 = \sqrt{2gh_1}$$

Step 2a: Find the time of flight, using the independence of the horizontal and vertical motion. Since the block leaves the table with zero *vertical* speed, the vertical kinematic equation $y = y_0 + v_{y0}t + \frac{1}{2}a_y t^2$ reduces to $h_2 = \frac{1}{2}gt^2$ (taking downward as positive). Solve for time to get $t = \sqrt{\frac{2h_2}{g}}$.

Step 2b. Find the horizontal distance d covered while in the air after point P. Since there are no horizontal forces exerted on the block, its horizontal velocity stays constant at v_1. So, the block travels a horizontal distance

$$d = v_1 t = \sqrt{2gh_1}\sqrt{\frac{2h_2}{g}} = 2\sqrt{h_1 h_2}$$

Distribution of points

(c)

i. 2 points

For mentioning a correct equation or step of reasoning (energy conservation on ramp) — 1 point

For correctly explaining why this equation or step mirrors the reasoning of (a)i — 1 point

Example: My energy conservation reasoning (part (b) step 1) mirrors my reasoning that a small ramp height corresponds to a low potential energy (mgh_1), which is converted into low kinetic energy and hence a low speed.

ii. 2 points

For mentioning a correct equation or step of reasoning (time of flight) — 1 point

For correctly explaining why that equation or step mirrors the reasoning of (a)ii — 1 point

Example: My time-of-flight calculation (part (b) step 2a) shows that t is proportional to $\sqrt{h_2}$, so a smaller falling distance h_2 corresponds to a smaller flight time.

(d) 1 point

Correct answer: "The same as"

Note: explanation is scored regardless of checkbox.

Point can be earned if response is consistent with answer in part (b)

For reasoning that is consistent with the functional dependence of the part (b) answer — 1 point

Example:

As found in part (b), the distance d does not depend on g. So, doing the experiment on the Moon instead of Earth makes no difference. The increased time of flight (since weaker gravity makes the block take longer to land) compensates for the small speed gained by the block on the ramp.

Checked "Greater than" then g must be in the denominator in the incorrect equation in part (b)

Checked "Less than" then g must be in the numerator in the incorrect equation in part (b)

Question 4

12 points total | **Distribution of points**

(a)

i, ii, and iii) 2 points

Note: Parts i, ii, and iii are read together
For measuring the mass or weight of the relevant system — 1 point
For making a measurement of force (or something from which a force can be calculated) with the fan turned on — 1 point

Note: fan angles of either 0° or 90° need not be measured directly, since these are given as the minimum and maximum angles possible. If the procedure involves intermediate angles, then these angles must be measured.

Example 1 (variant - Example 1a in parentheses):
(a)i The downward force exerted by the fan-block system (or "mass", as read on a balance, of the system)
(a)ii A spring scale (or mechanical balance)
(a)iii Set the fan angle to 90°. With the fan off, hang the system from a spring scale to find its weight (or place the system on a mechanical balance to find its mass). Turn the fan on, and record the force from the spring scale (or the mass reading from the mechanical balance).

Example 2:
(a)i Mass of the fan-block system and low-friction cart. Velocity of the cart as a function of time.
(a)ii Scale to measure mass. Motion detector to measure velocity as a function of time.
(a)iii Place the system and a low-friction cart on a scale to find the total mass of the fan-block and cart. Next, on a horizontal surface, place the fan-block on the cart, set the fan angle to zero, turn on the fan, and release the cart from rest. Use the motion detector to graph the cart velocity as a function of time.

iv) 1 point

For correctly indicating a method to determine the force exerted by air on the fan, using the measurements and procedure from parts (a) i, ii, and iii — 1 point

Example 1 (and 1a), continued from above:
Take the difference in the force readings with the fan off and the fan on. (1a: Multiply the difference in the mass readings by g). This difference is the force exerted by air on the fan.

Example 2, continued from above:
Estimate the average slope of the graph, which is the acceleration. Multiply acceleration by the total mass to find the force exerted by air on the fan.

Question 4 (continued)

Distribution of points

(b)

i. ii, and iii) 2 points

Note: Parts i. ii, and iii are read together
Note: In parts (b) i, ii, and iii, it is acceptable to say "the same as in part (a), with the following changes:", with changes to the procedure in part (a) then listed.

For describing measurements that would allow determination of the acceleration — 1 point

For describing a procedure that is practical/feasible in a school laboratory — 1 point

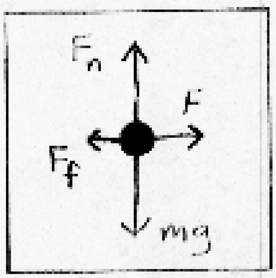
Example 3:
Place the fan-block on the track, with angle = 0. Place a motion detector behind it, set to graph velocity vs. time. Turn fan on, and release from rest. Repeat the procedure several times.

Example 4:
Place the fan-block on the track, with angle = 0. Place a photogate just in front of the block, and the second photogate a meter or two in front of the block. Measure distance from front of block to the front of that second photogate. Turn on fan and release the block from rest. The photogates measure the time it takes the block to travel the measured distance to the second photogate.

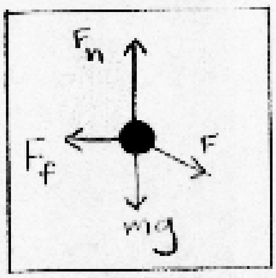
Example 5:
(b)i Angle of the fan. Velocity of fan-block system as a function of time.
(b)ii Protractor to measure the angle.
Motion detector to measure the velocity and time.
(b)iii Adjust the fan angle until the fan-block slides with a constant speed after being given a push. Use the motion detector to determine whether the speed is constant (zero slope on a graph of velocity as a function of time).

iv) 1 point

For correctly drawn and labeled vectors for the force exerted by air on fan and for the frictional force exerted on the block by the track, corresponding to the experiment described in part (b)iii. Other forces correctly drawn and labeled AND no incorrect forces, corresponding to the experiment described in part (b)iii. — 1 point



Examples 3 & 4



Example 5

4

Distribution of points

(c) 4 points

For using kinematic data to obtain acceleration, a, or showing that $a = 0$ — 1 point
Alternatively the point can be earned using the Work-Energy solution with kinetic energy $K = (1/2)mv^2$

For relating frictional force and coefficient of kinetic friction as $F_f = \mu_K F_N$ — 1 point

For a correct representation of the normal force, correctly referring back to a measurement of the fan-block system — 1 point

$F_N = mg$ if $\theta = 0$ or $F_N = mg + F\sin\theta$ if $\theta \neq 0$

For using Newton's second law, consistently with normal force above, for the appropriate forces or force components in the direction of the fan's motion that would lead to the determination of the coefficient of kinetic friction — 1 point

$F_{net} = ma$
$F - F_f = ma$

$$\mu_k = \frac{F - ma}{mg} \text{ if } \theta = 0 \text{ or } \mu_k = \frac{F\cos\theta - ma}{mg + F\sin\theta} \text{ if } \theta \neq 0$$

Alternatively the point can be earned using the Work-Energy solution that would lead to the determination of the coefficient of kinetic friction.

Example 3 (continued from above): $\theta = 0$ Determine the slope of each v vs. t graph, to get the acceleration for each trial, and average the accelerations. Call this average acceleration a. The kinetic frictional force exerted by track on block is $F_f = \mu F_n = \mu mg$, where m is the mass of the fan-block as found in part (a), since the acceleration is purely horizontal and hence F_n and mg must balance. So, by Newton's second law, letting F denote the force exerted by the air on the fan found in part (a), we get

$F_{net} = ma$
$F - F_f = ma$
$F - \mu mg = ma$

Solve for μ to get $\mu = \dfrac{F - ma}{mg}$

Example 4 (continued from above): $\theta = 0$ Let d denote distance from block to second photogate and t denote the corresponding time. Since $v_0 = 0$, $d = \frac{1}{2}at^2$ and hence $a = \dfrac{2d}{t^2}$. For each trial, calculate that acceleration, and take the average, which becomes our best estimate of a. [Rest of solution is as in example 3]

Question [redacted] (continued)
4

Distribution of points

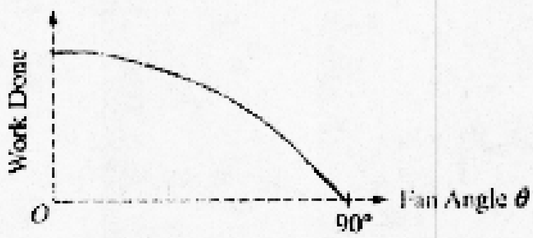
Example 5 (continued from above): $\theta = 0$ Since the acceleration is zero, the net horizontal force is zero. From Newton's second law.

$F_f = \mu mg = F\cos\theta$

Solving for μ_k:

$$\mu_k = \frac{F\cos\theta - ma}{mg + F\sin\theta} \text{ if } \theta \neq 0$$

(d) 2 points



A correct graph shows the work done as proportional to $\cos\theta$.

For showing a curve that continually decreases from a maximum value at 0° to a minimum value of zero at 90°	1 point
For showing a curve that is concave-downward (i.e. that has a negative second derivative)	1 point

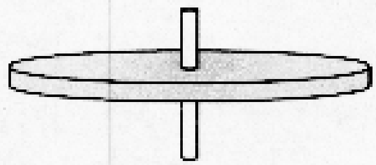
Mock 1 Exam

AP® PHYSICS 1

[redacted]ES

Question [redacted] 5

12 points total | **Distribution of points**



The disk shown above spins about the axle at its center. A student's experiments reveal that, while the disk is spinning, friction between the axle and the disk exerts a constant torque on the disk.

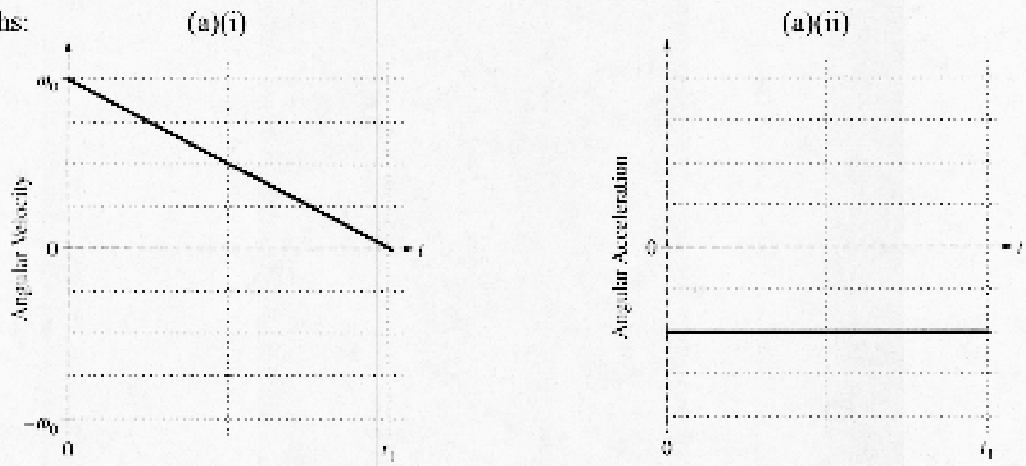
(a) [redacted]
4 points

At time $t = 0$ the disk has an initial counterclockwise (positive) angular velocity ω_0. The disk later comes to rest at time $t = t_1$.

i. On the grid at left below, sketch a graph that could represent the disk's angular velocity as a function of time t from $t = 0$ until the disk comes to rest at time $t = t_1$.

ii. On the grid at right below, sketch the disk's angular acceleration as a function of time t from $t = 0$ until the disk comes to rest at time $t = t_1$.

Example graphs:



i. 2 points

For a curve that has an angular velocity of $+\omega_0$ at time $t = 0$ and decreases to zero at time $t = t_1$		1 point
For a curve that is a straight line with a negative slope showing the angular velocity approaching zero (can be a positive slope, if the initial angular velocity on the graph is negative)		1 point

Question 5 [redacted] (continued)

Distribution of points

(a) (continued)

ii. 2 points

For a curve that is negative for the entire time		1 point
For a curve that is a constant nonzero function		1 point

(b) [redacted]
3 points

The magnitude of the frictional torque exerted on the disk is τ_0. Derive an equation for the rotational inertia I of the disk in terms of τ_0, ω_0, t_1, and physical constants, as appropriate.

For using an equation for the rotational version of Newton's second law		1 point
For using an appropriate rotational kinematics equation $\alpha = \Delta\omega / \Delta t$		1 point
For a correct answer in terms of the listed quantities, derived from first principles $I = \dfrac{\tau_0 t_1}{\omega_0}$ <u>Note</u>: This point is still earned if there is a minus sign, e.g., from using $-\tau_0$ or $-\omega_0$.		1 point

Alternate solution using angular momentum and rotational impulse:		
For defining and using angular momentum $L = I\omega$		1 point
For using rotational impulse $\Delta L = \tau \Delta t$		1 point
For a correct answer in terms of the listed quantities, derived from first principles $I = \dfrac{\tau_0 t_1}{\omega_0}$ *<u>Note</u>: This point is still earned if there is a minus sign, e.g., from using $-\tau_0$ or $-\omega_0$.*		1 point

5

Question [redacted] (continued)

Distribution of points

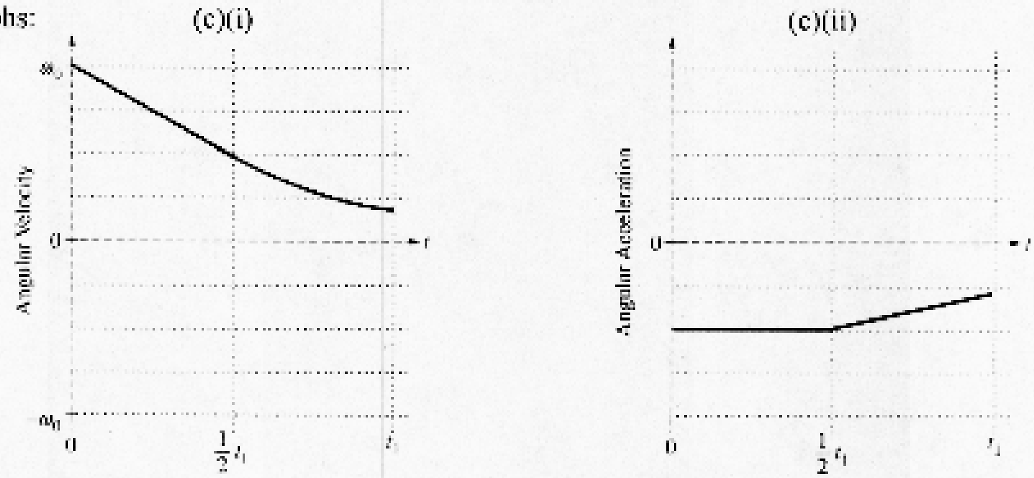
(c) [redacted]
4 points

In another experiment, the disk again has an initial positive angular velocity ω_0 at time $t = 0$. At time $t = \frac{1}{2}t_1$, the student starts dripping oil on the contact surface between the axle and the disk to reduce the friction. As time passes, more and more oil reaches that contact surface, reducing the friction even further.

i. On the grid at left below, sketch a graph that could represent the disk's angular velocity as a function of time from $t = 0$ to $t = t_1$, which is the time at which the disk came to rest in part (a).

ii. On the grid at right below, sketch the disk's angular acceleration as a function of time from $t = 0$ to $t = t_1$.

Example graphs:



i. 3 points

For curve with a clear change of slope or curvature at $\frac{1}{2}t_1$ and showing a decrease in speed thereafter		1 point
For a curve that indicates slowing at a decreasing rate between times $\frac{1}{2}t_1$ and t_1		1 point
For a curve that does not reach zero at or before time t_1		1 point

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5

Question [redacted] (continued)

Distribution of points

(c) (continued)

ii. 1 point

For a curve with decreasing magnitude between times $\frac{1}{2}t_1$ and t_1 Note: The acceleration may reach zero at or before time t_1. If so, it must remain zero for the remaining time.		1 point

(d) [redacted]

1 point

The student is trying to mathematically model the magnitude τ of the torque exerted by the axle on the disk when the oil is present at times $t > \frac{1}{2}t_1$. The student writes down the following two equations, each of which includes a positive constant (C_1 or C_2) with appropriate units.

(1) $\tau = C_1\left(t - \frac{1}{2}t_1\right)$ (for $t > \frac{1}{2}t_1$)

(2) $\tau = \dfrac{C_2}{\left(t + \frac{1}{2}t_1\right)}$ (for $t > \frac{1}{2}t_1$)

Which equation better mathematically models this experiment?

____ Equation (1) ____ Equation (2)

Briefly explain why the equation you selected is plausible and why the other equation is not plausible.

Correct answer: "Equation (2)" Note: If the wrong selection is made, the explanation is not graded.		
For stating that Equation (2) is plausible because the frictional torque decreases with increasing time, whereas in Equation (1) torque increases with increasing time		1 point
Examples: Equation (2) because τ decreases. In Equation (1), it doesn't. Equation (2) is plausible because the frictional torque decreases as more oil reaches the contact surface over time. Equation (1) is not plausible because it shows friction increasing as more oil reaches the surface over time.		