Past-paper walk-through

Potential Energy ▪ 3.3

eXercise

Questions in this set

- 2025 Q2
- 2022 Q1
- 2022 Q3
- 2019 Q3
- 2015 Q3

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 2

2025 ▪ Q2

A block of mass M is released from rest at position $x = 0$ near the top of a ramp. The ramp makes an angle of θ with the horizontal. The block slides down the ramp with negligible friction. At $x = 8D$ the block makes contact with an uncompressed spring with spring constant k. The spring is then compressed and the block momentarily comes to rest at $x = 12D$. Figure 1 shows the instants when the block is at $x = 0$, $x = 6D$, and $x = 10D$, respectively.
[Figure 1: Three diagrams of a ramp inclined at angle θ to the horizontal, with a spring of constant k fixed at the bottom of the ramp. The $+x$ direction points down the incline. Left diagram: block at $x = 0$ at the top of the ramp, with marks at $8D$ (where the spring begins, uncompressed) and $12D$ (spring fully compressed position) shown along the incline. Middle diagram: block shown partway down the ramp at

Question 2

$x = 6D$, moving toward the spring (motion lines shown). Right diagram: block shown further down, in contact with/compressing the spring, at $x = 10D$.]

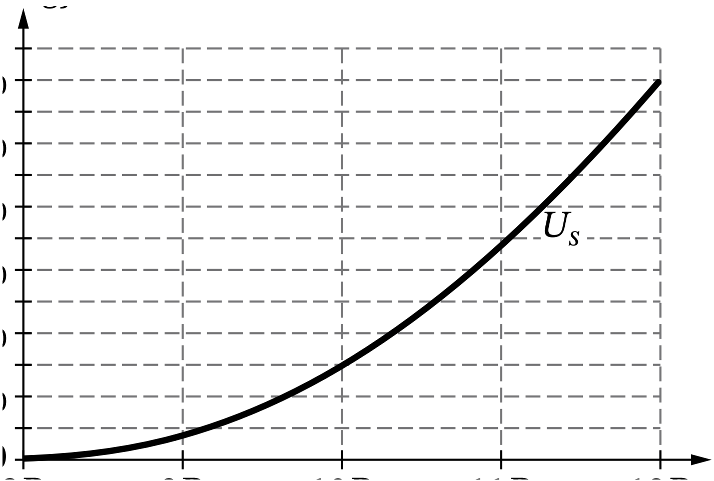
(a) Figure 4 shows an energy bar chart that represents the kinetic energy K of the block, the gravitational potential energy U_g of the block-spring-Earth system, and the spring potential energy U_s of the block-spring-Earth system at the instant that the block is at $x = 10D$. The gravitational potential energy U_g of the block-spring-Earth system is defined to be zero when the block momentarily comes to rest at $x = 12D$. **Draw** shaded bars that represent K, U_g, and U_s to complete the energy bar charts in Figure 2 and Figure 3 for when the block is released from rest at $x = 0$ and for when the block is at $x = 6D$, respectively.

- Shaded bars should start at the dashed line that represents zero energy. - Represent any energy that is equal to zero with a distinct line on the zero-energy line. - The

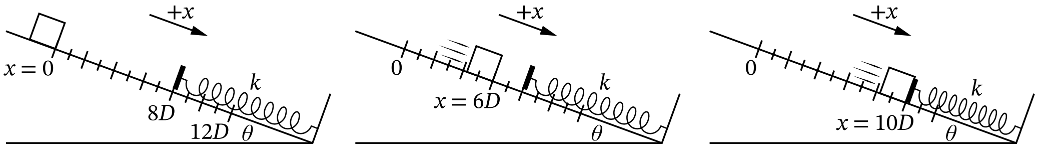
Question 2

relative heights of each shaded bar should reflect the magnitude of the respective energy consistent with the scale used in Figure 4.
[Figure 2: Bar chart titled "$x = 0$", vertical axis "Energy" gridded in increments of $2E_0$ from 0 to $14E_0$, with three empty bar slots labeled K, U_g, U_s on the horizontal axis — bars to be drawn by the student.]
[Figure 3: Bar chart titled "$x = 6D$", vertical axis "Energy" gridded in increments of $2E_0$ from 0 to $14E_0$, with three empty bar slots labeled K, U_g, U_s on the horizontal axis — bars to be drawn by the student.]
[Figure 4: Bar chart titled "$x = 10D$", vertical axis "Energy" gridded in increments of $2E_0$ from 0 to $14E_0$. Three shaded bars are shown: $K \approx 7E_0$, $U_g \approx 1.5E_0$, $U_s \approx 3E_0$.]

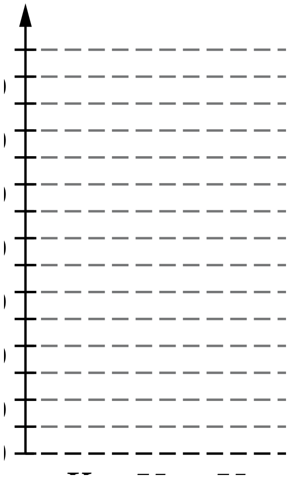
Question 2



Question 2



Question 2



Question 2

2025 ▪ Q2

A block of mass M is released from rest at position $x = 0$ near the top of a ramp. The ramp makes an angle of θ with the horizontal. The block slides down the ramp with negligible friction. At $x = 8D$ the block makes contact with an uncompressed spring with spring constant k. The spring is then compressed and the block momentarily comes to rest at $x = 12D$. Figure 1 shows the instants when the block is at $x = 0$, $x = 6D$, and $x = 10D$, respectively.

[Figure 1: Three diagrams of a ramp inclined at angle θ to the horizontal, with a spring of constant k fixed at the bottom of the ramp. The $+x$ direction points down the incline. Left diagram: block at $x = 0$ at the top of the ramp, with marks at $8D$ (where the spring begins, uncompressed) and $12D$ (spring fully compressed position) shown along the incline. Middle diagram: block shown partway down the ramp at $x = 6D$, moving toward the spring (motion lines shown). Right diagram: block shown further down, in contact with/compressing the spring, at $x = 10D$.]

Question 2

(b) Figure 5 shows the block at $x = 0$ when the block is released from rest and the block at $x = 12D$ when the block momentarily comes to rest against the compressed spring.
Figure 5
[Figure 5: Two diagrams of the same ramp at angle θ with spring constant k at the bottom. Left: block at $x = 0$ at the top, $+x$ direction down the incline, mark at $12D$ shown along the incline. Right: block at $x = 12D$, resting against the fully compressed spring at the bottom of the incline.]
Starting with conservation of energy, **derive** an equation for the spring constant k. Express your answer in terms of M, θ, D, and physical constants, as appropriate. Begin your derivation by writing a fundamental physics principle or an equation from the reference information.

Question 2

2025 ▪ Q2

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Question 2

(c)(i) Figure 6 shows a graph of the energy of the system as a function of the position of the block from $x = 8D$ to $x = 12D$. The spring potential energy U_s of the block-spring-Earth system is shown on the graph.

On the axes shown in Figure 6, **sketch** and **label** a line or curve that represents the total mechanical energy E for the block-spring-Earth system as a function of the position of the block from $x = 8D$ to $x = 12D$.

Figure 6

[Figure 6: Graph with vertical axis "Energy" gridded in increments of $2E_0$ from 0 to $12E_0$, horizontal axis "Position" marked $8D, 9D, 10D, 11D, 12D$. A curve labeled U_s is plotted starting at $(8D, 0)$ and increasing with upward curvature (quadratic-like shape) to reach $(12D, 12E_0)$. The student must add curves for E and U_g on the same axes.]

Question 2

(c)(ii) Sketch and **label** a line or curve that represents the gravitational potential energy U_g for the block-spring-Earth system as a function of the position of the block from $x = 8D$ to $x = 12D$.

Question 2

2025 ▪ Q2

A block of mass M is released from rest at position $x = 0$ near the top of a ramp. The ramp makes an angle of θ with the horizontal. The block slides down the ramp with negligible friction. At $x = 8D$ the block makes contact with an uncompressed spring with spring constant k. The spring is then compressed and the block momentarily comes to rest at $x = 12D$. Figure 1 shows the instants when the block is at $x = 0$, $x = 6D$, and $x = 10D$, respectively.

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Question 2

(d) Indicate whether the speed v_{9D} of the block at $x = 9D$ is greater than, less than, or equal to the speed v_{8D} of the block at $x = 8D$.

________ $v_{9D} > v_{8D}$

________ $v_{9D} < v_{8D}$

________ $v_{9D} = v_{8D}$

Justify how your response is consistent with the energy lines or curves you drew in Figure 6 in part C.

Solution 2

(a) Mark scheme

- Complete two energy bar charts, each totaling the constant mechanical energy $12E_0$. Figure 2 (block at $x = 0$, released from rest, not yet touching the spring): draw a single bar for U_g at height $12E_0$; the K and U_s bars are at zero. Figure 3 (block at $x = 6D$, partway down, still not touching the spring): draw bars for K and U_g only (no U_s), each at height $6E_0$. Point A1 for drawing one bar in Figure 2 that shows only U_g (the correct height is not required for this point); Point A2 for including only K and U_g bars in Figure 3 (correct heights not required); Point A3 for the bars in Figures 2 and 3 each totaling $12E_0$.

Solution 2

(b) Mark scheme

- By conservation of energy, the initial gravitational PE converts entirely into spring PE at the point where the block is momentarily at rest against the fully compressed spring: $E_0 = E_f \Rightarrow U_g = U_s \Rightarrow mg\Delta y = \frac{1}{2}k(\Delta x)^2$. Substituting $\Delta y = 12D\sin\theta$ (the height dropped along the incline from $x = 0$ to $x = 12D$) and $\Delta x = 4D$ (the spring compression, from $x = 8D$ to $x = 12D$): $Mg(12D\sin\theta) = \frac{1}{2}k(4D)^2$, which gives $k = \frac{3}{2}\frac{Mg\sin\theta}{D}$. Point B1 for a multistep derivation that includes conservation of energy; B2 for equating U_g to U_s; B3 for substituting $12D\sin\theta$ for Δy OR $4D$ for Δx in the respective energy expression; B4 for a correct expression for k (any algebraic equivalent of $k = \frac{3}{2}\frac{Mg\sin\theta}{D}$). A correct, isolated final expression for k earns B2, B3, and B4.

Solution 2

(c)(i)

Mark scheme

- Sketch a horizontal line at $E = 12E_0$, drawn continuously from $x = 8D$ to $x = 12D$, labeled to indicate it is the total mechanical energy E of the block-spring-Earth system (constant, since no non-conservative forces act). Point C1.

Solution 2

(c)(ii)

Mark scheme

- Sketch a straight, decreasing line (linear, since $U_g = Mg(12D - x)\sin\theta$ is linear in x) from $x = 8D$ to $x = 12D$, labeled to indicate gravitational potential energy U_g, starting at the point $(8D,\ 4E_0)$ and decreasing to $(12D,\ 0)$. Point C2 for a decreasing straight line labeled as gravitational potential energy; Point C3 for starting that line at $(8D, 4E_0)$.

Solution 2

(d) Mark scheme

- $v_{9D} > v_{8D}$. Justification: from the total-energy line ($E = 12E_0$ everywhere) and the U_g line drawn in part C, at $x = 8D$, $U_g = 4E_0$, so $K = 12E_0 - 4E_0 = 8E_0$ (with $U_s \approx 0$ there). At $x = 9D$, U_g has dropped to about $3E_0$ and U_s is still less than E_0, so $K = E - U_g - U_s > 12E_0 - 3E_0 - E_0 = 8E_0$. Since the kinetic energy — and therefore the speed — is greater at $x = 9D$ than at $x = 8D$, $v_{9D} > v_{8D}$. Point D1 for the comparison consistent with the student's part-C graph (whichever position has the smaller $U_g + U_s$ has the larger speed); Point D2 for a justification consistent with that graph that correctly relates speed to U_g, U_s, and either K or total energy E.

Question 1

2022 ▪ Q1

Two blocks are connected by a string that passes over a pulley, as shown above. Block 1 is on a horizontal surface and is attached to a spring that is at its unstretched length. Frictional forces are negligible in the pulley's axle and between the block and the surface. Block 2 is released from rest and moves downward before momentarily coming to rest.

k_0 is the spring constant of the spring.

M_1 is the mass of block 1.

M_2 is the mass of block 2.

Δy is the distance block 2 moves before momentarily coming to rest.

[Figure: A horizontal tabletop with a spring of constant k_0 attached to a wall on the left, connected to Block 1 (M_1) resting on the table. A string runs from Block 1

Question 1

horizontally to a pulley at the right edge of the table, then down to a hanging Block 2 (M_2), which is shown displaced a distance Δy downward from its initial position.]

(a)(i) Block 2 starts from rest and speeds up, then it slows down and momentarily comes to rest at a position below its initial position. In terms of only the forces directly exerted on block 2, explain why block 2 initially speeds up and explain why it slows down to a momentary stop.

(a)(ii) Derive an expression for the distance Δy that block 2 travels before momentarily coming to rest. Express your answer in terms of k_0, M_1, M_2, and physical constants, as appropriate.

Question 1

Diagram A: Negligible Friction

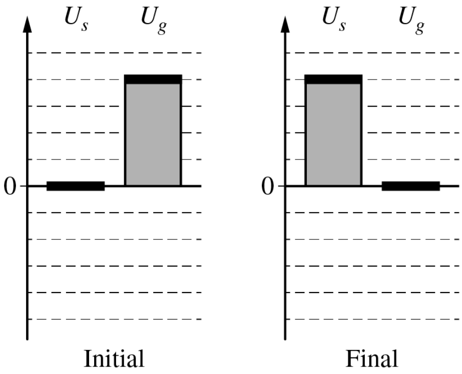
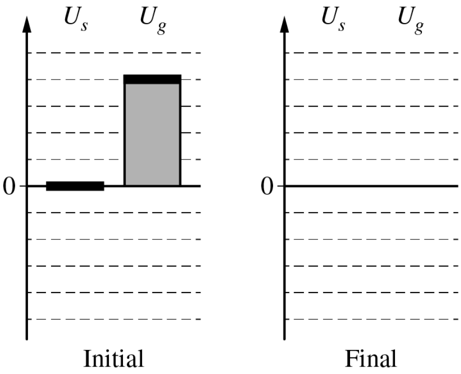
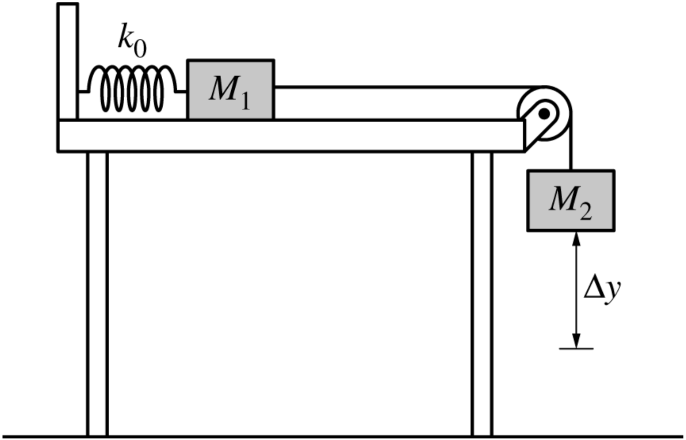


Diagram B: Nonnegligible Friction



Question 1



Question 1

2022 ▪ Q1

Two blocks are connected by a string that passes over a pulley, as shown above. Block 1 is on a horizontal surface and is attached to a spring that is at its unstretched length. Frictional forces are negligible in the pulley's axle and between the block and the surface. Block 2 is released from rest and moves downward before momentarily coming to rest.
k_0 is the spring constant of the spring.
M_1 is the mass of block 1.
M_2 is the mass of block 2.
Δy is the distance block 2 moves before momentarily coming to rest.
[Figure: A horizontal tabletop with a spring of constant k_0 attached to a wall on the left, connected to Block 1 (M_1) resting on the table. A string runs from Block 1 horizontally to a pulley at the right edge of the table, then down to a hanging Block 2 (M_2), which is shown displaced a distance Δy downward from its initial position.]

Question 1

(b) Indicate whether the total mechanical energy of the blocks-spring-Earth system changes as block 2 moves downward.

____ Changes ____ Does not change

Briefly explain your reasoning.

Question 1

2022 ▪ Q1

Two blocks are connected by a string that passes over a pulley, as shown above. Block 1 is on a horizontal surface and is attached to a spring that is at its unstretched length. Frictional forces are negligible in the pulley's axle and between the block and the surface. Block 2 is released from rest and moves downward before momentarily coming to rest.

k_0 is the spring constant of the spring.

M_1 is the mass of block 1.

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[Figure: A horizontal tabletop with a spring of constant k_0 attached to a wall on the left, connected to Block 1 (M_1) resting on the table. A string runs from Block 1 horizontally to a pulley at the right edge of the table, then down to a hanging Block 2 (M_2), which is shown displaced a distance Δy downward from its initial position.]

Question 1

(c) Consider the system that includes the spring, Earth, both blocks, and the string, but not the surface. Let the initial state be when the blocks are at rest just before they start moving, and let the final state be when the blocks first come momentarily to rest. Diagram A below is a bar chart that represents the energies in the scenario where there is negligible friction between block 1 and the surface.

The shaded-in bars in the energy bar charts represent the potential energy of the spring and the gravitational potential energy of the blocks-Earth system, U_s and U_g, respectively, in the initial and final states. Positive energy values are above the zero-point line ("0") and negative energy values are below the zero-point line.

[Diagram A: Negligible Friction — two bar charts labeled "Initial" and "Final", each with two bars U_s and U_g, on a vertical axis with a zero-point line "0". Initial: U_s bar is a thin sliver just above 0 (near zero), U_g bar is tall, extending well above 0. Final: U_s

Question 1

bar extends above 0 to a moderate height, U_g bar is a thin sliver just below 0 (near zero, slightly negative).]
[Diagram B: Nonnegligible Friction — two bar charts labeled "Initial" and "Final", each with two bars U_s and U_g. Initial state already provided: U_s bar is a thin sliver just above 0, U_g bar is tall extending well above 0 (same as Diagram A's initial state). Final state is blank/empty, to be completed by the student.]
Complete diagram B (at right above) for the scenario in which friction is nonnegligible. The energies for the initial state are already provided. Shade in the energies in the final state using the same scale as in diagram A.

- Shaded regions should start at the solid line representing the zero-point line.
- Represent any energy that is equal to zero with a distinct line on the zero-point line.

Solution 1

(a)(i) Mark scheme

- Block 2 speeds up while the gravitational force (weight, W) exerted on it is greater than the tension (T) in the string (net force and acceleration point downward, in the direction of motion). As Block 2 falls, the spring (connected to Block 1) stretches further, increasing the tension until T becomes greater than W; the net force and acceleration then point upward (opposite the velocity), decelerating Block 2 until it momentarily stops. Scoring: 1 point for relating the net force to acceleration/change in velocity; 1 point for a correct description of the relative magnitudes of T and W during the motion (both T>W initially and T<W later) – the spring force must be connected to the string tension, not treated as acting directly on Block 2.

Solution 1

(a)(ii)

Mark scheme

- Conservation of energy for the blocks-spring-Earth system (K$_i = K_f = 0) : U_{g,i} + M_2 g \Delta y = U_{g,f} + \frac{1}{2} k_0 \Delta y^2, i.e. M_2 g \Delta y = \frac{1}{2} k_0 \Delta y^2, so M_2 g = \frac{1}{2} k_0 \Delta y, giving \Delta y = \frac{2 M_2 g}{k_0}. Scoring : 1 point for a correct energy - conservation equation including both a gravitational PE term and a spring PE term; 1 point for the corr$
  $2 M_2 g / k_0 depending only on M_2, k_0, and g.$

Solution 1

(b)

Mark scheme

- Does not change. There are no external forces doing work on the system and no energy is dissipated by friction, so the total mechanical energy of the blocks-spring-Earth system stays the same (energy only transforms between gravitational PE, spring PE, and KE). Scoring: 1 point for selecting "Does not change" with a correct explanation.

Solution 1

(c)

Mark scheme

- With non-negligible friction between Block 1 and the surface, mechanical energy is lost to friction as the blocks move, so at the final state (Block 2 momentarily at rest, $K\_f=0$) the total spring PE (U_s) plus gravitational PE (U_g) must be less than the initial total of 4 units. The final bar chart must show both $U\_s>0$ and $U\_g>0$ (both bars positive), with $U\_s+U\_g < 4$ units. Scoring: 1 point for a final bar chart where both U_s and U_g are positive; 1 point for a final bar chart where the sum of U_s and U_g is less than four units.

Question 3

2022 ▪ Q3

[Figure: A wheel mounted on a horizontal axle, standing on a support post above a floor. A string is wrapped around the wheel's rim and hangs down to a small hanging block. Labels: "Wheel" (top, pointing to the wheel), "Axle" (pointing to the horizontal axle at the wheel's center), "Hanging Block" (pointing to the small block hanging from the string), "Floor" (the ground below).]

A wheel is mounted on a horizontal axle. A light string is attached to the wheel's rim and wrapped around it several times, and a small block is attached to the free end of the string, as shown in the figure. When the block is released from rest and begins to fall, the wheel begins to rotate with negligible friction.

Question 3

Two students are discussing how different forms of energy change as the block falls. One student says that the kinetic energy of the block increases as it falls. The second student says that this is because gravitational potential energy is converted to kinetic energy. The students decide to test whether the decrease in gravitational potential energy is equal to the increase in the block's kinetic energy from when the block starts moving to immediately before it reaches the floor.

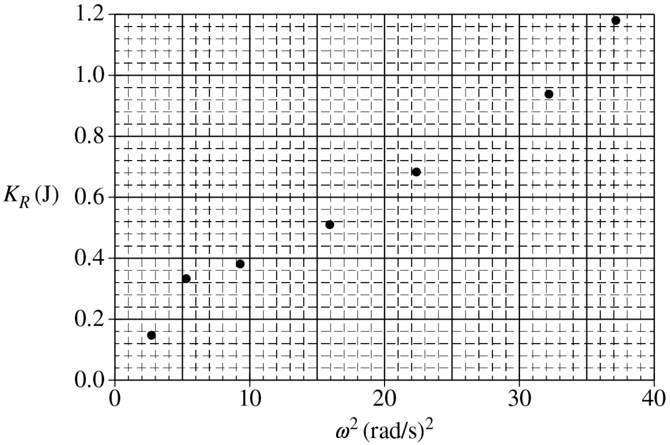
(a) Design an experimental procedure that the students could use to compare the increase in the block's translational kinetic energy with the decrease in the gravitational potential energy of the block-Earth system as the block falls.

Question 3

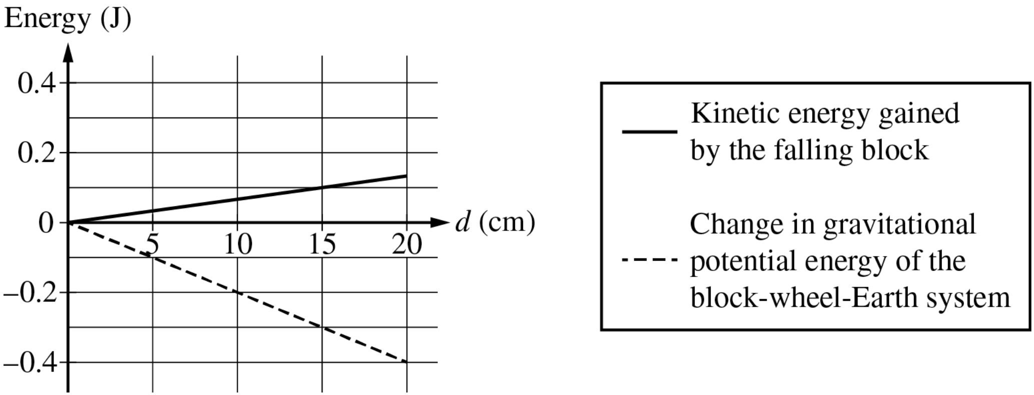
In the table, list the quantities that would be measured in your experiment. Define a symbol to represent each quantity and list the equipment that would be used to measure each quantity. You do not need to fill in every row. If you need additional rows, you may add them in the space just below the table.
In the space to the right of the table, describe the overall procedure. Provide enough detail so that another student could replicate the experiment, including any steps necessary to reduce experimental uncertainty. As needed, use the symbols defined in the table.
If needed, you may include a simple diagram of the setup with your procedure.

Quantity to Be Measured	Symbol for Quantity	Equipment for Measurement	Procedure (and diagram, if needed)

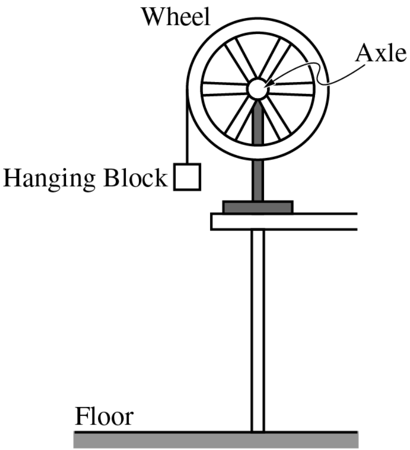
Question 3



Question 3


Energy (J)
0.4
0.2
0
–0.2
–0.4
5
10
15
20
d (cm)
Kinetic energy gained by the falling block
Change in gravitational potential energy of the block-wheel-Earth system

Question 3



Question 3

2022 ▪ Q3

[Figure: A wheel mounted on a horizontal axle, standing on a support post above a floor. A string is wrapped around the wheel's rim and hangs down to a small hanging block. Labels: "Wheel" (top, pointing to the wheel), "Axle" (pointing to the horizontal axle at the wheel's center), "Hanging Block" (pointing to the small block hanging from the string), "Floor" (the ground below).]

A wheel is mounted on a horizontal axle. A light string is attached to the wheel's rim and wrapped around it several times, and a small block is attached to the free end of the string, as shown in the figure. When the block is released from rest and begins to fall, the wheel begins to rotate with negligible friction.

Two students are discussing how different forms of energy change as the block falls. One student says that the kinetic energy of the block increases as it falls. The second student says that this is because gravitational potential energy is converted to kinetic energy. The students decide to test whether the decrease in gravitational potential energy is equal to the increase in

Question 3

the block's kinetic energy from when the block starts moving to immediately before it reaches the floor.

(b) Explain how the students could determine the kinetic energy of the block immediately before it reaches the floor using the quantities you indicated in the table in part (a).

Question 3

2022 ▪ Q3

[Figure: A wheel mounted on a horizontal axle, standing on a support post above a floor. A string is wrapped around the wheel's rim and hangs down to a small hanging block. Labels: "Wheel" (top, pointing to the wheel), "Axle" (pointing to the horizontal axle at the wheel's center), "Hanging Block" (pointing to the small block hanging from the string), "Floor" (the ground below).]

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Question 3

the block's kinetic energy from when the block starts moving to immediately before it reaches the floor.

(c) [Graph: "Energy (J)" on the y-axis from -0.4 to 0.4 J (gridlines at $-0.4, -0.2, 0, 0.2, 0.4$), "*d* (cm)" on the x-axis from 0 to 20 cm (gridlines at 5, 10, 15, 20). A solid line labeled "Kinetic energy gained by the falling block" starts near $(0, 0)$ and rises gently to about $(20, 0.15)$. A dashed line labeled "Change in gravitational potential energy of the block-wheel-Earth system" starts near $(0, 0)$ and falls to about $(20, -0.35)$.]

The graph above represents both the change in the gravitational potential energy of the block-wheel-Earth system and the translational kinetic energy gained by the block as functions of the block's falling distance *d*. On the graph, draw a line or curve to represent the rotational kinetic energy of the wheel as a function of the block's falling distance *d*.

Question 3

2022 ▪ Q3

[Figure: A wheel mounted on a horizontal axle, standing on a support post above a floor. A string is wrapped around the wheel's rim and hangs down to a small hanging block. Labels: "Wheel" (top, pointing to the wheel), "Axle" (pointing to the horizontal axle at the wheel's center), "Hanging Block" (pointing to the small block hanging from the string), "Floor" (the ground below).]

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Question 3

the block's kinetic energy from when the block starts moving to immediately before it reaches the floor.

(d)(i) The students also measure the angular velocity ω of the wheel as the block falls and determine the rotational kinetic energy K_R of the wheel. The students then make a graph of K_R as a function of ω^2, as shown.

[Graph: "K_R (J)" on the y-axis from 0.0 to 1.2 J (gridlines at 0.0, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2), "ω^2 (rad/s)^2" on the x-axis from 0 to 40 (gridlines at 0, 10, 20, 30, 40). Data points (approximate): $(5, 0.15)$, $(8, 0.28)$, $(10, 0.35)$, $(17, 0.5)$, $(24, 0.65)$, $(32, 0.95)$, $(35, 1.15)$.]

On the above graph, draw a straight line that best represents the data.

(d)(ii) Using the line you drew for part (d)(i), calculate an experimental value for the rotational inertia of the wheel.

Solution 3

(a) Mark scheme

- Design: measure the mass m_B of the block with a mass balance; hold the block with the string taut and measure the fall distance d (initial height above the floor) with a meterstick; release the block and use a stopwatch to measure the fall time t_B (start at release, stop when the block hits the floor); repeat 3 trials at the same d and repeat for several different values of d to reduce uncertainty (e.g. by averaging). Table: Mass of block m_B – mass balance; Distance block falls d – meterstick; Time for block to fall t_B – stopwatch. Scoring (1 point each): listing relevant equipment matching the measured quantities; listing measurements sufficient to determine the block's kinetic energy; listing measurements sufficient to determine the gravitational PE of the block-Earth system; a plausible procedure

Solution 3

(can be done in a typical school physics lab); attempting to reduce uncertainty (e.g. repeated trials/averaging).

Solution 3

(b)

Mark scheme

- Compute the block's average speed as d$/$t$_B$; $sinceitfallsfromrestwithconstantacceleration, thef$ $2d/t_B. ThenthefinalkineticenergyisK = \frac{1}{2}m_B v_F^2 = \frac{1}{2}m_B(2d/t_B)^2. Scoring :$ $1 pointforindicatingthatmassandvelocityareneeded (neednotbethefinalvelocity); 1 pointforavalic$

Solution 3

(c) Mark scheme

- On the Energy vs. d graph, draw a straight line through the origin with positive slope representing the kinetic energy gained by the falling block, and a line representing the change in gravitational PE such that the total energy sum is (approximately) zero at all values of d – the correct line passes through the origin and through (15 cm, 0.2 J), so that KE gained plus the (negative) change in PE sums to zero, showing energy conservation. Scoring: 1 point for drawing a straight line that passes through the origin and has a positive slope; 1 point for drawing a line that yields a total energy sum of zero at all values of d.

Solution 3

(d)(i)

Mark scheme

- On the $K_R vs. \omega^2 graph, drawareasonablebest-fitstraightlinethroughtheplotteddatapoints.Scor$
  $1 pointfordrawingareasonablebest - fitline.$

Solution 3

(d)(ii)

Mark scheme

- From the best-fit line, slope $= \dfrac{1.04 - 0.20}{35 - 2.5} = 0.0258\ \text{kg}\cdot\text{m}^2. Since K_R = \dfrac{1}{2} I\omega^2, the slope of K_R vs. \omega^2 equals \dfrac{1}{2} I, so I = 2 \times \text{slope} = 0.0517\ \text{kg}\cdot\text{m}^2. Scoring : 1 point for correctly calculating a value for the slope using points on the drawn line (or stating a calculate$

Question 3

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[Figure 1: "Uncompressed spring" — a coiled spring attached at its left end to a fixed wall, with a plate attached at its free (right) end. Below the spring, a pin is shown pointing to position A; positions A, B, C are marked along the axis of the spring near the plate, with A closest to the wall/spring and C closest to the plate's resting position, in increasing order of compression.]
[Figure 2: "Compressed spring" — the same spring shown compressed, with a steel sphere placed against the plate. Positions A, B, C are marked along the same axis; the plate (and sphere) is shown pinned at position C, indicating maximum compression among the three shown positions.]
A projectile launcher consists of a spring with an attached plate, as shown in Figure 1. When the spring is compressed, the plate can be held in place by a pin at any of three positions A, B, or C. For example, Figure 2 shows a steel sphere placed against the

Question 3

plate, which is held in place by a pin at position C. The sphere is launched upon release of the pin.

A student hypothesizes that the spring constant of the spring inside the launcher has the same value for different compression distances.

(a)(i) The student plans to test the hypothesis by launching the sphere using the launcher.

State a basic physics principle or law the student could use in designing an experiment to test the hypothesis.

(a)(ii) Using the principle or law stated in part (a)(i), determine an expression for the spring constant in terms of quantities that can be obtained from measurements made with equipment usually found in a school physics laboratory.

Question 3

Quantity to be Measured	Symbol for Quantity	Equipment for Measurement

Question 3

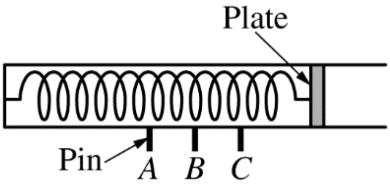

Figure 1. Uncompressed spring

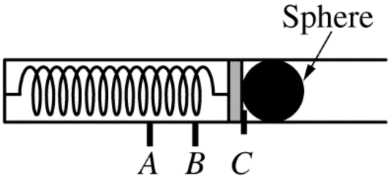

Figure 2. Compressed spring

Question 3