2025 MCAS Sample Student Work and Scoring Guide

High School Introductory Physics
Question 42: Constructed-Response

Reporting Category: Energy
Practice Category: Mathematics and Data
Standard: HS.PHY.3.1 - Use algebraic expressions and the principle of energy conservation to calculate the change in energy of one component of a system when the change in energy of the other component(s) of the system, as well as the total energy of the system including any energy entering or leaving the system, is known. Identify any transformations from one form of energy to another, including thermal, kinetic, gravitational, magnetic, or electrical energy, in the system.
Item Description: Calculate the work done to lift two people, describe how the work done on the people affects their gravitational potential energy, describe how the gravitational potential energy and kinetic energy of an object change as the object falls to the ground, and calculate the velocity of the object just before it hits the ground.

This item can be found in the released item sets on the MCAS Resource Center.

Scoring Guide

Select a score point in the table below to view the sample student response.

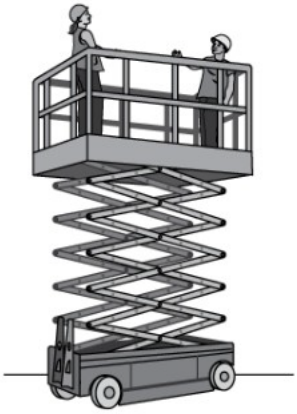
Score*	Description
4A	The response demonstrates a thorough understanding of work and changes in energy. The response correctly calculates the work done by a hoist to lift two people. The response clearly describes how the work done by the hoist compares to the change in gravitational potential energy of the people. The response clearly describes what happens to a beam's gravitational potential energy and kinetic energy as it falls to the ground. The response also correctly calculates the velocity of the beam just before it hits the ground.
4B	
3	The response demonstrates a general understanding of work and changes in energy.
2	The response demonstrates a limited understanding of work and changes in energy.
1	The response demonstrates a minimal understanding of work and changes in energy.
0	The response is incorrect or contains some correct work that is irrelevant to the skill or concept being measured.

*Letters are used to distinguish between sample student responses that earned the same score (e.g., 4A and 4B).

Score Point 4A

This question has four parts.

A material hoist is a device used to lift or lower heavy loads. The illustration shows a material hoist lifting two people whose combined mass is 160 kg.



Part A

Calculate the work done by the hoist to lift the two people 15 m. Show your calculations and include units in your answer.

B I U MATH

$F_g = mg$
$F_g = 160(10)$
$F_g = 1600\ N$
$W = Fd$
$W = 1600\ (15)$
$W = 24000\ J$

Maximum number of characters: 1500 || Characters remaining: 1500

Part B

Describe how the work done by the hoist to lift the two people 15 m compares to the change in gravitational potential energy of the two people. Support your answer by referring to variables in both the work and potential energy formulas.

The work done by the hoist and the change in gravitational potential energy are equal. The formula for work is W = Fd where F = mg so by substitution, W = mgd. The formula for gravitational potential energy is PE = mgΔ h. Since the hoist only went up, Δ h is equal to d. Therefore, work is equal to the gravitational potential energy.

Maximum number of characters: 1500 || Characters remaining: 1232

Part C

The hoist is used to lift a 70 kg wooden beam to a height of 20 m. The beam then falls off the hoist.

Describe what happens to the beam's gravitational potential energy **and** the beam's kinetic energy as it falls to the ground.

As the beam is raised, the gravitational potential energy for the beam increases until it reaches 20 m. Once the beam is dropped, the gravitational potential energy is transformed into kinetic energy until it hits the ground.

Maximum number of characters: 1500 || Characters remaining: 1311

Part D

Calculate the velocity of the 70 kg beam just before it hits the ground. Show your calculations and include units in your answer.

$PE = mg\Delta h$
$PE = 70(10)(20)$
$PE = 14000\ J$
$\Delta PE = \Delta KE$
$14000\ J = \Delta KE$
$KE = \frac{1}{2}mv^2$
$14000 = \frac{1}{2}(20)(v)^2$
$14000 = 35(v)^2$
$400 = v^2$
$20\ \frac{m}{s} = v$

Maximum number of characters: 1500 || Characters remaining: 1500

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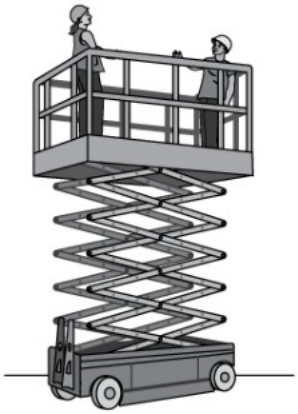
Score Point 4B

This question has four parts.

A material hoist is a device used to lift or lower heavy loads. The illustration shows a material hoist lifting two people whose combined mass is 160 kg.



Part A

Calculate the work done by the hoist to lift the two people 15 m. Show your calculations and include units in your answer.

W = Fd
F = mg = 1600 N
d = 15 m
W = (1600 N) (15 m)
= 24000 J
The work done by the material hoist is 24000 J

Maximum number of characters: 1500 || Characters remaining: 1427

Part B

Describe how the work done by the hoist to lift the two people 15 m compares to the change in gravitational potential energy of the two people. Support your answer by referring to variables in both the work and potential energy formulas.

The work and potential energy in this situation are the same. This can be proven by looking at the formulas for both forms of energy. The formula for potential energy is PE = mgΔ h. The mass of the object, the acceleration of gravity, and the change in height are all used. These variables are the same as the variables use in W=Fd, the formula for work. Mass multiplied by the acceleration of gravity is force and the distance is height. This shows that both are equal.

Maximum number of characters: 1500 || Characters remaining: 1117

Part C

The hoist is used to lift a 70 kg wooden beam to a height of 20 m. The beam then falls off the hoist.

Describe what happens to the beam's gravitational potential energy **and** the beam's kinetic energy as it falls to the ground.

When the beam falls to the ground, its potential energy decreases and its kinetic energy increases.

Maximum number of characters: 1500 || Characters remaining: 1416

Part D

Calculate the velocity of the 70 kg beam just before it hits the ground. Show your calculations and include units in your answer.

$PE = mg\Delta h$

$m = 70\ kg \quad g = 10\ \frac{m}{s^2} \quad \Delta h = 20\ m$

$PE = (70\ kg)\left(10\ \frac{m}{s^2}\right)(20\ m) = 14000\ J$

$14000 = \frac{1}{2}(70)v^2$

$28000 = (70)v^2$

$400 = v^2$

$\sqrt{400} = v = 20\ \frac{m}{s}$

The velocity of the beam is $20\ \frac{m}{s}$.

Maximum number of characters: 1500 || Characters remaining: 1500

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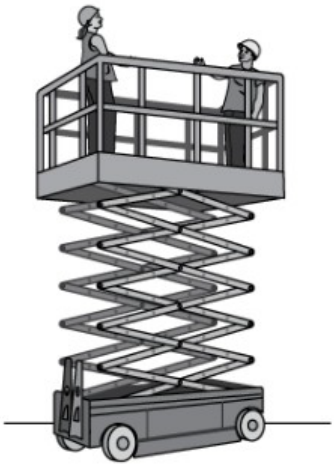
Score Point 3

This question has four parts.

A material hoist is a device used to lift or lower heavy loads. The illustration shows a material hoist lifting two people whose combined mass is 160 kg.



Part A

Calculate the work done by the hoist to lift the two people 15 m. Show your calculations and include units in your answer.

$W = Fd$
$W = -1600\ N \cdot 15\ m$
$W = -24000\ J$
$F = ma$
$F = 160\ kg \cdot -10\ \frac{m}{s^2}$
$F = -1600\ N$

Maximum number of characters: 1500 || Characters remaining: 1500

Part B

Describe how the work done by the hoist to lift the two people 15 m compares to the change in gravitational potential energy of the two people. Support your answer by referring to variables in both the work and potential energy formulas.

$PE = mg\Delta h$

$PE = 160\ kg \cdot -10\ m/s^2 \cdot 15m$

$PE = -24000J$

The work done by the hoist and the change in GPE of the two people are the same. Since the mg in the PE formula is equivalent to weight or force, and change in height is the same as distance, then solving for work and solving for PE you will get equal amounts.

Maximum number of characters: 1500 || Characters remaining: 1292

Part C

The hoist is used to lift a 70 kg wooden beam to a height of 20 m. The beam then falls off the hoist.

Describe what happens to the beam's gravitational potential energy **and** the beam's kinetic energy as it falls to the ground.

As the beam falls to the ground, its GPE is decreasing while its KE is increasing. This is because GPE is energy due to position or height and KE is energy of moving things. Since the height of the beam is decreasing then so would its GPE, and since the beam is starting to move, then its KE is increasing.

Maximum number of characters: 1500 || Characters remaining: 1253

Part D

Calculate the velocity of the 70 kg beam just before it hits the ground. Show your calculations and include units in your answer.

$KE = \frac{1}{2}mv^2$

$-24000\ J = \frac{1}{2} \cdot 70\ kg \cdot v^2$

$\frac{-24000\ J}{-35} = \frac{35 \cdot v^2}{-35}$

$\sqrt{+685.71\ J} = \sqrt{v^2}$

$+26.19\ \frac{m}{s} = v$

Maximum number of characters: 1500 || Characters remaining: 1500

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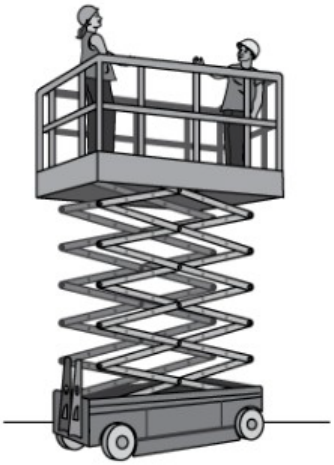
Score Point 2

This question has four parts.

A material hoist is a device used to lift or lower heavy loads. The illustration shows a material hoist lifting two people whose combined mass is 160 kg.



Part A

Calculate the work done by the hoist to lift the two people 15 m. Show your calculations and include units in your answer.

B I U MATH

W = Fd F = 160 N d = 15 m $160\ N \cdot 15\ m = 2400\ J$

Maximum number of characters: 1500 || Characters remaining: 1485

Part B

Describe how the work done by the hoist to lift the two people 15 m compares to the change in gravitational potential energy of the two people. Support your answer by referring to variables in both the work and potential energy formulas.

PE=mgΔ h. In this case, m is the same as F and Δ h is the same as d. The only difference between work formula and potential energy formula is g in PE, which is around 10 m/s^2 . That would make potential energy about 10 times stronger than work.

Maximum number of characters: 1500 || Characters remaining: 1308

Part C

The hoist is used to lift a 70 kg wooden beam to a height of 20 m. The beam then falls off the hoist.

Describe what happens to the beam's gravitational potential energy **and** the beam's kinetic energy as it falls to the ground.

As the beam falls, it looses gravitational potential energy and gains kinetic energy. Gravitational potential energy relies on the height from the ground, so by falling, the gravitational potential energy decreases. Instead, the gravitational potential energy becomes kinetic energy.

Maximum number of characters: 1500 || Characters remaining: 1255

Part D

Calculate the velocity of the 70 kg beam just before it hits the ground. Show your calculations and include units in your answer.

First I found the PE since PE becomes KE while falling down, KE must equal PE.

$PE = mg\Delta h \quad m = 70 \quad g = 10 \quad \Delta h = 20$

$70\ m \cdot 10\ \frac{m}{s^2} \cdot 20\ m = 14000$

$KE = \frac{1}{2}mv^2 \quad KE = 14000 \quad m = 70 \quad v = ?$

$14000 = \left(\frac{1}{2} \cdot 70 \cdot v^2\right)$

$\frac{28000}{70} = \frac{70v^2}{70}$

$1400 = 1v^2$

$20 = v$

The velocity must be 20 m/s.

Maximum number of characters: 1500 || Characters remaining: 1477

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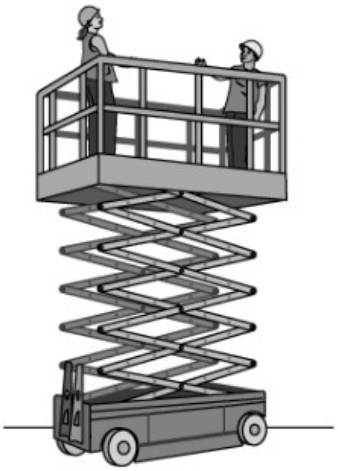
Score Point 1

This question has four parts.

A material hoist is a device used to lift or lower heavy loads. The illustration shows a material hoist lifting two people whose combined mass is 160 kg.



Part A

Calculate the work done by the hoist to lift the two people 15 m. Show your calculations and include units in your answer.

B I U MATH

W = Fd W = 160 kg x 15 m = 2,400 Joules

Maximum number of characters: 1500 || Characters remaining: 1473

Part B

Describe how the work done by the hoist to lift the two people 15 m compares to the change in gravitational potential energy of the two people. Support your answer by referring to variables in both the work and potential energy formulas.

The gravitational potential energy of the two workers is greater than the work done because gravity (9.8) is a factor in potential energy.
PE = 23,520 J W = 2,400 J

Maximum number of characters: 1500 || Characters remaining: 1366

Part C

The hoist is used to lift a 70 kg wooden beam to a height of 20 m. The beam then falls off the hoist.

Describe what happens to the beam's gravitational potential energy **and** the beam's kinetic energy as it falls to the ground.

The beam gains gravitational potential energy as its being lifted by the hoist. As the beam falls to the ground, it loses potential energy and gains kinetic energy.

Maximum number of characters: 1500 || Characters remaining: 1363

Part D

Calculate the velocity of the 70 kg beam just before it hits the ground. Show your calculations and include units in your answer.

$$KE = PE$$
$$\frac{1}{2}mv^2 = mgh$$
$$\frac{\frac{1}{2} \times 70kg \times v^2}{70kg} = \frac{70kg \times 9.8 \times 20m}{70kg}$$
$$\frac{1}{2} \times v^2 = \times 9.8 \times 20m$$
$$\frac{v^2}{2} = \frac{19.6m}{2}$$
$$\sqrt{v^2} = \sqrt{98m}$$
$$v = 9.89 \ \frac{m}{s}$$

The velocity of the beam equals 9.8 m/s.

Maximum number of characters: 1500 || Characters remaining: 1500

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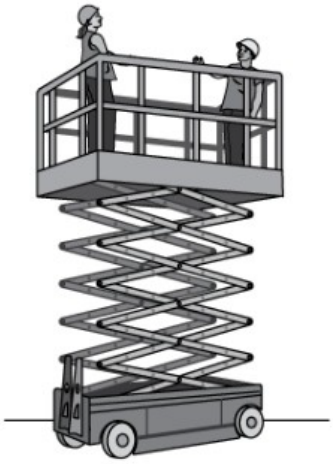
Score Point 0

This question has four parts.

A material hoist is a device used to lift or lower heavy loads. The illustration shows a material hoist lifting two people whose combined mass is 160 kg.



Part A

Calculate the work done by the hoist to lift the two people 15 m. Show your calculations and include units in your answer.

F=160 kg
m= 15 m
$\frac{160}{15} = 10.6666$
10.6666 W

Maximum number of characters: 1500 || Characters remaining: 1480

Part B

Describe how the work done by the hoist to lift the two people 15 m compares to the change in gravitational potential energy of the two people. Support your answer by referring to variables in both the work and potential energy formulas.

Work is done by the hoist to lift the two people because it compares the change in gravitational potential energy of the two people.

Maximum number of characters: 1500 || Characters remaining: 1391

Part C

The hoist is used to lift a 70 kg wooden beam to a height of 20 m. The beam then falls off the hoist.

Describe what happens to the beam's gravitational potential energy **and** the beam's kinetic energy as it falls to the ground.

The beam's gravitational potential energy and the beam's kinetic energy falls to the ground while it's happening.

Maximum number of characters: 1500 || Characters remaining: 1403

Part D

Calculate the velocity of the 70 kg beam just before it hits the ground. Show your calculations and include units in your answer.

$\frac{70\ kg}{15}$

4.6

v=4.6

Maximum number of characters: 1500 || Characters remaining: 1500

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