Phys 100
Fall 2023

Concepts of Physics: Test 2

day month 2023

Name: Solution **Total:** /50

Instructions

- There are 14 questions on 8 pages.
- Show your reasoning and calculations and always explain your answers.

Physical constants and useful formulae

$$\text{speed} = \frac{\text{distance traveled}}{\text{time elapsed}} \qquad s = \frac{d}{t}$$

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time elapsed}} \qquad a = \frac{v}{t}$$

$$\text{distance} = \frac{1}{2} \times \text{acceleration} \times \text{time}^2 \qquad d = \frac{1}{2} \times a \times t^2$$

$$\text{final speed} = \text{initial speed} + \text{acceleration} \times \text{time} \qquad v_f = v_i + a \times t$$

$$\text{acceleration} = \frac{\text{net force}}{\text{mass}} \qquad a = \frac{F}{m}$$

$$\text{earth's gravitational force} = \text{mass} \times 9.8 \qquad F_{\text{grav earth}} = m \times 9.8$$

$$\text{KE} = \frac{1}{2} \times \text{mass} \times (\text{speed})^2 \qquad KE = \frac{1}{2} m \times v^2$$

$$\text{speed} = \sqrt{2 \times \text{KE/mass}} \qquad v = \sqrt{\frac{2 \times KE}{m}}$$

$$\text{gravPE} = \text{mass} \times 9.8 \times \text{height} \qquad PE = m \times 9.8 \times h$$

$$\text{height} = \frac{\text{gravPE}}{\text{mass} \times 9.8} \qquad h = \frac{PE}{m \times 9.8}$$

$$\text{power} = \frac{\text{energy gain}}{\text{time elapsed}} \qquad P = \frac{E}{t}$$

$$\text{energy} = \text{power} \times \text{time elapsed} \qquad E = P \times t$$

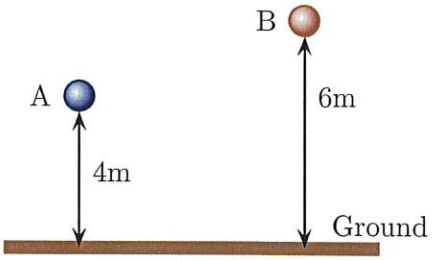
$$\text{efficiency} = \frac{\text{useful energy output}}{\text{energy input}} \qquad \varepsilon = \frac{E_{\text{output}}}{E_{\text{input}}}$$

$$\text{useful energy output} = \text{efficiency} \times \text{energy input} \qquad E_{\text{output}} = \varepsilon \times E_{\text{input}}$$

$$\text{energy input} = \frac{E_{\text{output}}}{\text{efficiency}} \qquad E_{\text{input}} = \frac{E_{\text{output}}}{\varepsilon}$$

Question 1

Two balls are thrown upward above the ground. Ball A has mass 4 kg and ball B has mass 2 kg. At a given moment their positions are as illustrated and ball A moves up with speed 8 m/s while ball B moves up with speed 10 m/s.



a) Which of the following (choose one) is true?

i) A has a larger kinetic energy than B.
ii) A has a smaller kinetic energy than B.
iii) A has the same kinetic energy as B.

$K_A = \frac{1}{2} \times 4\text{kg} \times (8\text{m/s})^2 = 128\text{J}$

$K_B = \frac{1}{2} \times 2\text{kg} \times (10\text{m/s})^2 = 100\text{J}$

b) Which of the following (choose one) is true?

i) A has a larger potential energy than B.
ii) A has a smaller potential energy than B.
iii) A has the same potential energy as B.

$PE_A = 4\text{kg} \times 9.8\text{m/s}^2 \times 4\text{m} = 157\text{J}$

$PE_B = 2\text{kg} \times 9.8\text{m/s}^2 \times 6\text{m} = 118\text{J}$

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Question 2

A 0.40 kg ball is thrown upwards and has total energy 12 J. Determine its *potential energy* and its *height* above the ground at the moment that it reaches its maximum height above the ground.

At max height $KE = 0 \Rightarrow E = KE + PE \Rightarrow 12\text{J} = 0 + PE$

$\Rightarrow PE = 12\text{J}$

$$\text{height} = \frac{PE}{\text{mass} \times 9.8\,\text{m/s}^2} = \frac{12\text{J}}{0.40\text{kg} \times 9.8\,\text{m/s}^2} = 3.1\text{m}$$

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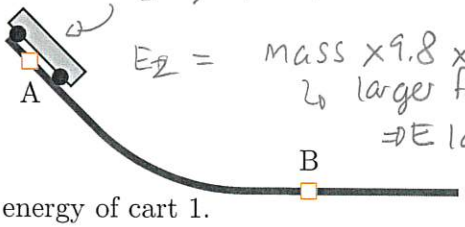
Question 3

Two carts are initially released from rest on identical ramps. They are both released from the same location (point A). Cart 1 has mass 50 kg and cart 2 has mass 80 kg. Which of the following (choose one) is true when they reach point B?



$E_1 = KE_1^{0} + PE_1 = \text{mass} \times 9.8 \times \text{height}$

$E_2 = \text{mass} \times 9.8 \times \text{height}$

$\rightarrow$ larger for 2

$\Rightarrow E$ larger for 2

i) The total energy of cart 2 is the same as the total energy of cart 1.
ii) The total energy of cart 2 is larger than the total energy of cart 1.
iii) The total energy of cart 2 is smaller than the total energy of cart 1.

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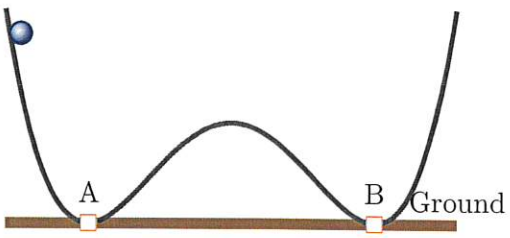
Question 4

A 0.25 kg ball is released from rest at the illustrated the point on a track. This is 4.0 m above the ground. The ball slides down the frictionless track without any air resistance.



a) Determine the total energy of the ball at the moment when it is released. +2

$E = KE + PE$

$KE = \frac{1}{2}\,\text{mass} \times (\text{speed})^2 = \frac{1}{2}\,0.25\text{kg} \times (0\text{m/s})^2 = 0\text{J}$

$PE = \text{mass} \times 9.8 \times \text{height} = 0.25\text{kg} \times 9.8\text{m/s}^2 \times 4.0\text{m} = 9.8\text{J}$

$\Rightarrow E = 9.8\text{J}$

+2 b) Determine the kinetic and potential energies at point A.

$E = 9.8\text{J}$

$PE = \text{mass} \times 9.8 \times \text{height}$

$= 0.25\text{kg} \times 9.8\text{m/s}^2 \times 0 = 0$

$E = KE + PE$

$9.8\text{J} \quad 9.8\text{J} \quad 0$

+1 c) Determine the speed of the ball at point A.

$\text{speed} = \sqrt{\frac{2KE}{\text{mass}}} = \sqrt{\frac{2 \times 9.8\text{J}}{0.25\text{m}}} = 8.9\text{m/s}$

speed = 8.9 m/s.

+1 d) Explain whether the speed of the ball at B is the same as, larger than or smaller than the speed of the ball at A.

Same: Total energy is same at A, B. There is no potential energy at A, B $\Rightarrow$ KE = total energy $\Rightarrow$ KE same $\Rightarrow$ speed same.

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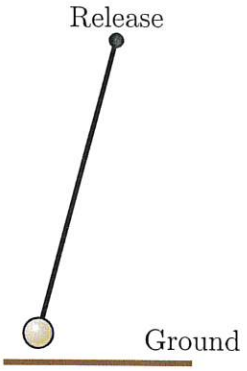
Question 5

A 3.0 kg pendulum (a small ball that swings from a string) is released from rest at the indicated position. The gravitational potential energy of the pendulum at the moment that it is released is 54 J. Determine the speed of the pendulum as it passes the ground level.



At release $E = KE + PE = 0J + 54J$

$\downarrow$ 0J at rest $= 54J$

At lowest point $E = KE + \cancel{PE}^{0} \Rightarrow 54J = KE$

$$\text{Speed} = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{2 \times 54J}{3.0kg}} = 6.0 m/s$$

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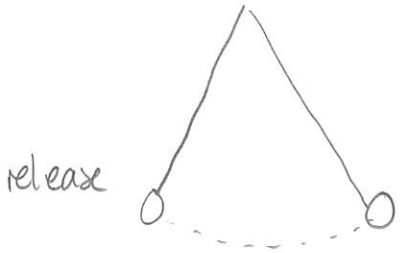
Question 6

A student who understands the laws of physics but has never seen a pendulum volunteers for a demonstration involving a heavy ball attached by a cable to the ceiling. The student stands with his back to the wall and the ball is pulled aside so that it almost touches his nose. The ball is released and swings back and forth. Use energy to explain whether the student needs to worry or not about the ball hitting his nose at it returns.



At highest point there is no kinetic energy $\Rightarrow$ energy = PE

since energy is conserved, at highest point PE is same as release energy.

$PE = mass \times 9.8 \times height$

$\Rightarrow$ height is same.

Pendulum will reach start point

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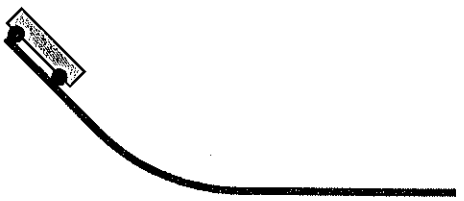
Question 7

A car is initially at rest at the top of an incline and is released. It reaches the bottom of the incline and slides for some distance along the horizontal section until it stops. Which of the following (choose one) is true of the sum of kinetic and potential energies, $KE + PE$?



i) $KE+PE$ stays constant throughout the motion.
ii) $KE + PE$ increases throughout the motion.
iii) $KE + PE$ decreases throughout the motion.

PE drops (decreases)
KE starts at zero ends at zero
=> KE+PE decreases)

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Question 8

A fluorescent bulb is on for 10min and uses 600J of energy. An incandescent bulb is on for 2min and uses 300J of energy. For which bulb is the power used the greatest? Explain your answer.

Power = $\frac{\text{energy}}{\text{time}}$

fluorescent: $P = \frac{600J}{600s}$ time = $10m \times \frac{60s}{min}$ = 600s

= 1W

incandescent. $P = \frac{300J}{120s} = 2.5W$

incandescent, larger

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Question 9

Three bulbs each take electric energy input and produce light energy output. These are described in the table. Which of the following (choose one) describes the correct rank of the **efficiencies** of the bulbs?

i) Green largest, red middle, blue smallest.
ii) Red largest, green middle, blue smallest
iii) Green largest, blue middle, red smallest.
iv) Blue largest, green middle, red smallest.

Light	Electric E	Light E	Light E / Electric E. Efficiency
Red	300J	60J	0.20
Green	200J	80J	0.40
Blue	80J	40J	0.50

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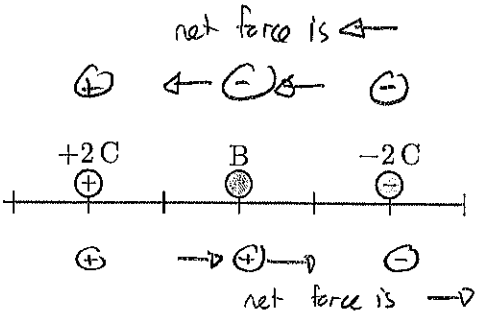
Question 10

Three charged particles are held fixed as illustrated. The particles on the end have exactly opposite charges. Various charged particles can be placed in the middle location (B). Which of the following (choose one) is true regarding the net force on B?



i) The net force is zero regardless of whether B is positive or negative.
ii) The net force is zero if B is positive and not zero if B is negative.
iii) The net force is not zero if B is positive and zero if B is negative.
iv) The net force is not zero regardless of whether B is positive or negative.

Both are non-zero

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Question 11

Three charged particles are held at fixed locations. The distances between adjacent charges are the same and the sizes of their charges are the same. The charge on the left (A) is initially held at rest and is then released. After it is released, which way will it begin to move? Explain your answer.

B repels A → larger because B is closer

C attracts A

⇒ net force is left

⇒ acceleration left

⇒ A moves left.

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Question 12

Magnesium chloride is a type of salt that consists of magnesium ions and chlorine ions. Each magnesium ion is produced from a neutral magnesium atom (12 electrons, 12 protons and 12 neutrons) that has lost *two electrons*. Each chlorine ion is produced from a neutral chlorine atom (17 electrons, 17 protons and 18 neutrons) that has gained *one electron*. Explain how many chlorine ions will need to combine with each magnesium ion to form a neutral combination.

magnesium has charge $2 \times 1.6 \times 10^{-19} C$

chlorine ion " " $1 \times (-1.6 \times 10^{-19} C)$

Neutral requires two chlorine for one magnesium

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Question 13

An alpha particle consists of two protons and two neutrons. Such alpha particles are fired toward the nucleus of a gold atom. Which of the following (choose one) is true as the alpha particle approaches the gold nucleus?

i) The nucleus exerts an attractive force on the alpha particle.
ii) The nucleus exerts a repulsive force on the alpha particle.
iii) The nucleus does not exert any force on the alpha particle.

like charges repel.

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Question 14

A current of 0.0020 A flows through a part of a circuit in an electronic device.

a) Determine the total charge that flows through this part of the circuit in 2 minutes (120 s).

charge = current × time → 2 min × 60 s/min = 120 s

= 0.0020 A × 120 s = 0.240 C

b) The current consists of electrons. Determine the total number of electrons that flow through this part of the circuit in 2 minutes (120 s).

$$\text{number electrons} = \frac{\text{total charge}}{\text{charge one electron}}$$

$$= \frac{0.240\,C}{1.6\times10^{-19}\,C} = 1.5\times10^{18}$$

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