Phys 100
Fall 2022

Concepts of Physics: Test 2

26 October 2022

Name: SOLUTION **Total:** /50

Instructions

- There are 13 questions on 8 pages.
- Show your reasoning and calculations and always explain your answers.

Physical constants and useful formulae

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Question 1

A 2 kg ball is held at rest 4 m above the surface of the Earth. A 4 kg box is held at rest 2 m above the surface of the Earth. Which (choose one) of the following is true regarding their gravitational potential energies (PE)?

i) PE for the box is same as PE for the ball.
ii) PE for the box is smaller than PE for the ball.
iii) PE for the box is larger than PE for the ball.

Briefly explain your choice.

PE = mass x 9.8 x height.

For 2kg PE = 2x9.8 x 4m = 59
For 4kg PE = 4x9.8 x 2m = 59

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Question 2

Two carts, A and B, each have mass 10 kg. Cart A moves with speed twice that of cart B. Which (choose one) of the following is true regarding their kinetic energies (KE)?

i) KE for the cart A is two times KE for cart B.
ii) KE for the cart A is four times KE for cart B.
iii) KE for the cart A is one half KE for cart B.
iv) KE for the cart A is one quarter KE for cart B.

$K = \frac{1}{2}mv^2 = \frac{1}{2} \times 10 \times v^2 = 5 \times v^2$

speed twice $= 2(\text{speed})^2 = 4$

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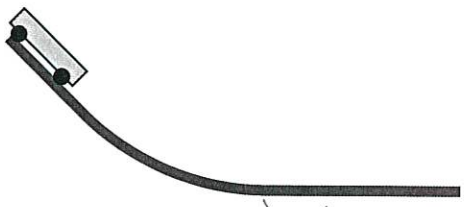
Question 3

A car slides from rest at the top of an incline. The car descends and eventually reaches a stop along the horizontal section. Which of the following statements (choose one) is true?



i) Initial and final kinetic energies are zero and gravitational PE stays constant so total energy is conserved.
ii) Initial and final kinetic energies are zero and gravitational PE decreases so the total energy decreases.
iii) Total energy is not conserved in real situations like this; it is only conserved in idealized physics examples.
iv) None of the above. These exclude thermal energy.

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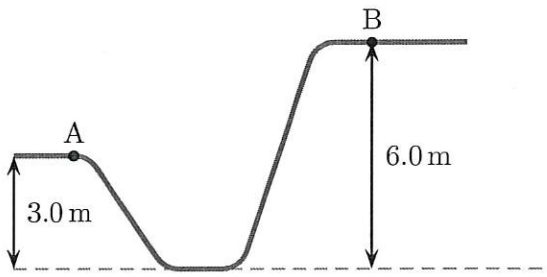
Question 4

A skater, with mass 80 kg, moves left to right on the illustrated track. Ignore friction and air resistance. At point A the skater has speed 5.0 m/s.



a) Determine the total energy of the skater.

At A

KE = $\frac{1}{2}$ × mass × (speed)^2 = $\frac{1}{2}$ × 80kg × (5.0 m/s)^2 = 1000J] +1

PE = mass × 9.8 × height = 80 × 9.8 × 3 = 2352J] +1

⇒ E = 1000J + 2352J = 3352J.] +2

b) Does the skater reach point B? Explain your answer.

It would require at least PE = mass × 9.8 × height

= 80 × 9.8 × 6 = 4704 J] ~~+2~~ +1

This is more energy than the skater has

NO +1

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Question 5

A balloon falls toward the ground, passing a point 2 m above the ground falling at a constant speed of 5 m/s. It continues falling toward the ground at the same constant speed. Consider the gravitational potential energy at the moment when it is 2 m above the ground. Into what forms of energy is this converted as the balloon continues to the ground? Explain your answer.

PE decreases
KE constant
Therm E increases
} converted into Therm E

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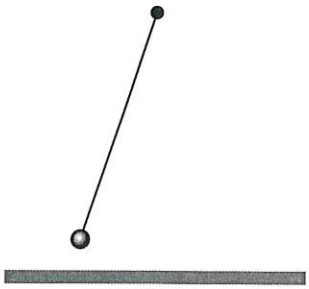
Question 6

A 20 kg pendulum is released from rest at a height 0.60 m above the ground. The pendulum swings and at its lowest point is just barely above the surface of the Earth.



a) Determine the kinetic energy, the potential energy and the total energy of the pendulum at the instant that it is released.

$KE = \frac{1}{2} \times \text{mass} \times (\text{speed})^2 = \frac{1}{2} \times 20\text{kg} \times 0^2 = 0\text{J}$

$PE = \text{mass} \times 9.8\text{m/s}^2 \times \text{height} = 20\text{kg} \times 9.8\text{m/s}^2 \times 0.60\text{m} = 118\text{ J}$

$E = 0\text{ J} + 116\text{J} = 116\text{J}$ +3

b) Determine the kinetic energy of the pendulum when it is at the lowest point of its swing.

Here $PE = 0$, $E = 116\text{J}$ $\Rightarrow$ $KE = 116\text{J}$ +1

c) Determine speed of the pendulum when it is at the lowest point of its swing.

$$V = \sqrt{\frac{2\,KE}{m}}$$

$$= \sqrt{\frac{2 \times 116}{20}} = 3.4\text{m/s}$$ +2

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Question 7

Two students illuminate their rooms with a single light bulbs. Alice uses a 20 W light bulb which she runs for 20 minutes. Bob has a 10 W bulb which he runs for 50 minutes. Which of the following is true?

$E = P \times \text{time}$

i) Alice's bulb uses more energy than Bob's bulb.
ii) Alice's bulb uses less energy than Bob's bulb.
iii) Alice's bulb uses the same energy as Bob's bulb.

Alice $20 \times (20 \times 60\text{s}) = 24000\text{J}$

Bob $10 \times (50 \times 60\text{s}) = 30000\text{J}$

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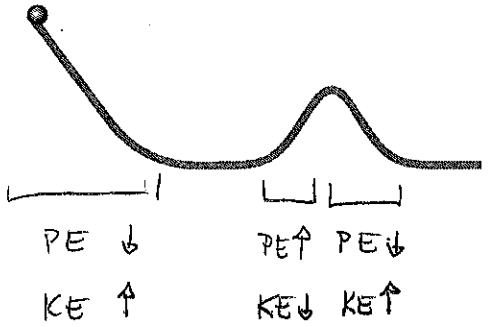
Question 8

A ball is initially at rest at the top of the illustrated frictionless track and is released. It slides from left to right along the track. Air resistance is negligible.



a) Describe the sections of track (if any) along which the gravitational potential energy decreases and those along which it increases.

Decreases when it descends

Increases when it ascends

b) Describe the sections of track (if any) along which the kinetic energy decreases and and those along which it increases.

Decreases when it ascends

Increases " it descends

c) Describe the sections of track (if any) along which the total energy decreases and and those along which it increases.

Always constant

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Question 9

A battery uses 2000 J of chemical energy to produce 600 J of useful electric energy. Determine the efficiency of the battery.

$$\varepsilon = \frac{\text{useful out}}{\text{input}} = \frac{600\,\text{J}}{2000\,\text{J}} = 0.30$$

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Question 10

Several proposals for engines are described using the following data about the energy per cycle of operation.

	Input Thermal Energy	Waste Thermal Energy
Engine A	200 J	0 J
Engine B	500 J	100 J
Engine C	1000 J	150 J

useful out | eff
200 J | $\frac{200}{200}=1$
400 J | $\frac{400}{500}=0.8$
850 J | $\frac{850}{1000}=0.85$

a) Ignoring whether such engines are possible or not, which of the following (choose one) ranks these in terms of efficiency?

i) All the same efficiency.

ii) A lowest, B middle, C highest efficiency.

(iii) B lowest, C middle, A highest efficiency.

iv) C lowest, B middle, A highest efficiency.

b) Which of these engines is physically possible? Explain your answer.

Cannot have efficiency = 1. There must be some waste

⇒ B, C.

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Question 11

Two pieces of Scotch tape are pulled off a roll of tape. Explain why they repel each other when they are held near to each other.

They become charged when they are pulled off.

The charges are same ⇒ they repel.

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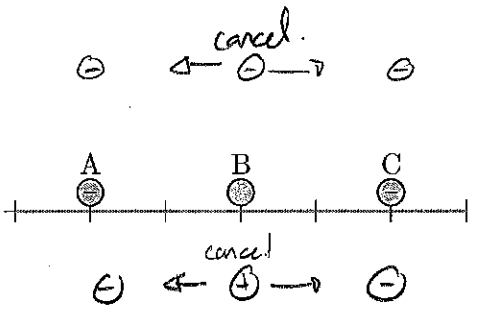
Question 12

Three charged particles are held fixed along a straight lines as illustrated. The particles on the left and right ends are identical. Various charged particles can be placed in the middle location (B).



Which of the following (choose one) is true regarding the net force on the charge at B?

i) The net force is zero regardless of whether B is positive or negative.
ii) The net force is to the right regardless of whether B is positive or negative.
iii) The net force is to the left regardless of whether B is positive or negative.
iv) The net force is to the right if the charge at B is negative and to the left if the charge at B is positive.
v) The net force is to the right if the charge at B is positive and to the left if the charge at B is negative.

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Question 13

Table salt consists of a regular array of sodium and chlorine atoms.

a) Will a neutral sodium atom exert any electric force on a neutral chlorine atom? Explain your answer.

No they are not charged.

b) Explain how electric forces can be used to describe how sodium and chlorine atoms can be held together in a stable arrangement.

The atoms become ions * sodium positive
* chlorine negative

electric forces attract to hold them together.

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