# Concepts of Physics: Test 1

29 September 2023

**Name:** Solution **Total:** /50

## Instructions

- There are 14 questions on 6 pages.
- Show your reasoning and calculations and always explain your answers.

## Physical constants and useful formulae

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

$$\text{acceleration} = \frac{\text{change in speed}}{\text{time elapsed}} \qquad a = \frac{s}{t}$$

$$\text{change in speed} = \text{acceleration} \times \text{time elapsed} \qquad s = a \times t$$

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

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

$$\text{net force} = \text{mass} \times \text{acceleration} \qquad F = ma$$

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

$$\text{gravitational force} = 6.67 \times 10^{-11} \times \frac{\text{mass}_1 \times \text{mass}_2}{\text{distance}^2} \qquad F_{\text{grav}} = 6.67 \times 10^{-11} \times \frac{m_1 \times m_2}{d^2}$$

## Question 1

Consider a simple geocentric model of planetary motion in which the planets circle the Earth at constant rates and a heliocentric model such as that offered by Copernicus. Which of the following is true?

i) Both models describe retrograde motion of the planets.
(ii) Only the heliocentric model describes retrograde motion of the planets.
iii) Only the simple geocentric model describes retrograde motion of the planets.
iv) Neither model describes retrograde motion of the planets.

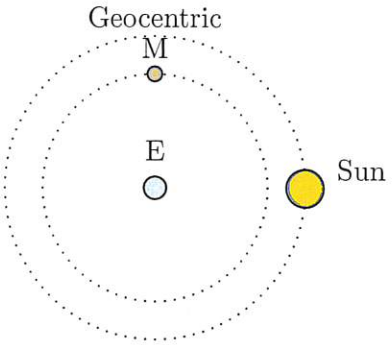
/3

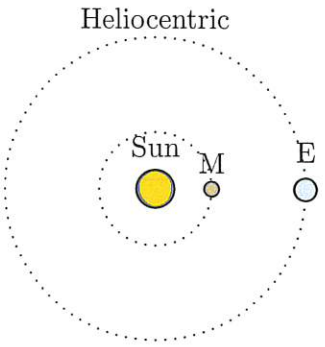
## Question 2

Consider the following two models of the planet Mercury in the solar system:

- Geocentric model where Sun and Mercury orbit the Earth at different rates,
- Heliocentric model where Earth and Mercury orbit the Sun at different rates.

The rate refers to the amount of time that it takes to complete one orbit.
For *each* model, does the model predict that Mercury can be observed from Earth at midnight? Explain your answer.
Explain *how* you could use the possibility of observing Mercury from Earth at midnight to decide which of the two models could be correct.




Geocentric

would be able to see at midnight


Heliocentric

To see at midnight need E between S and M. This never occurs.

We could use this as:

* observe at midnight
  - if see Mercury → geocentric could be correct, heliocentric not
  - if do not see " → geocentric could not be ", heliocentric could

/6

Temperature drops → atoms move more slowly
→ collisions with walls less frequent
→ press decreases

## Question 3

A party balloon contains Helium. The balloon is cooled and its temperature drops. Which of the following (choose one) describes the effect of the temperature drop on the pressure of the gas in the balloon?

i) The pressure stays constant; the number of atoms stays the same.
ii) The pressure increases; the atoms collide more frequently with each other.
iii) The pressure increases; the atoms collide more frequently with the balloon walls.
iv) The pressure decreases; the atoms collide ~~more~~ less frequently with each other.
v) The pressure decreases; the atoms collide ~~more~~ less frequently with the balloon walls.

/3

## Question 4

Suppose that you want to estimate the number of quarters (25c coins) in the US. One way to do this is to estimate roughly how many quarters each person in the US has. Assume that the coins in the US are owned by people over the age of 18. There are about 260 million people in the US over the age of 18. If each has approximately 3 quarters, then determine the approximate number of quarters in the US.

total number $= 3 \times 260\,000\,000$

$= 3 \times 2.6 \times 10^8$

$= 7.8 \times 10^8$

/4

## Question 5

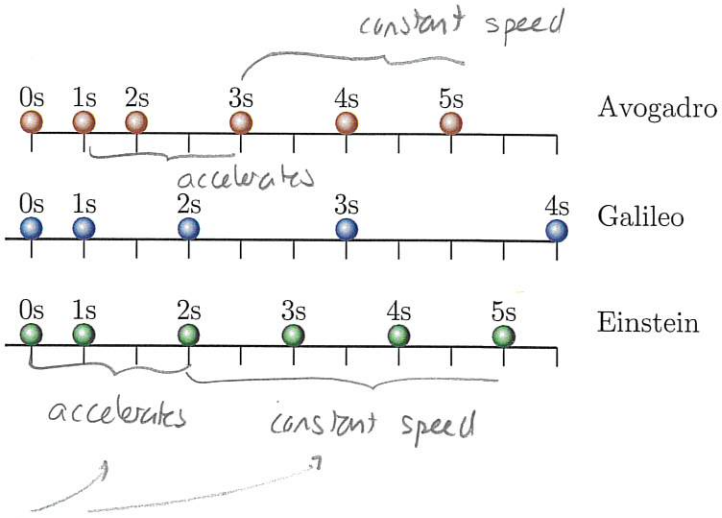
Consider the number 0.000056. To which if the following (choose one) is this equivalent?

i) $5.6 \times 10^5$
ii) $5.6 \times 10^4$
iii) $5.6 \times 10^{-4}$
iv) $5.6 \times 10^{-5}$
v) $5.6 \times 10^{-6}$

/3

## Question 6

A ball moves horizontally from left to right. A data recorder records the speed and acceleration of the ball. It reports that from 0 s to 2 s, the ball accelerates and then from 2 s to 4 s it moves with constant speed. Three students reconstruct the position of the ball every second. Their depictions are illustrated. Whose depiction is correct? Explain your choice.




Einstein is correct.

/4

## Question 7

A mouse and an elephant each run in a straight line. During a period of 5.0 s the mouse speeds up from 0.0 m/s to 10.0 m/s and the elephant speeds up from 8.0 m/s to 13.0 m/s. Is the acceleration of the mouse during this period smaller than, larger than or equal to the acceleration of the elephant? Explain you choice.

Accel = $\frac{\text{change speed}}{\text{time elapsed}}$

elephant accel = $\frac{13\,m/s - 8\,m/s}{5\,s} = 1.0\,m/s^2$

mouse

accel = $\frac{10\,m/s - 0\,m/s}{5\,s} = 2.0\,m/s^2$

mouse larger

/4

## Question 8

A hockey puck slides across an ice surface, which is frictionless and horizontal. Air resistance is negligible and the puck slides with constant high speed in a straight line. A spectator states that "At all times while the puck is sliding at high speed, there must be a large force acting on the puck to keep the puck moving with high speed." Is this correct or not? Explain your answer.

No. The net force on the puck is zero. Since there is no friction and no air resistance, no other force is needed

/3

Force = mass x accel

## Question 9

Three cars each move in a straight line. At one instant their speeds and accelerations are measured. This information, together with their masses is provided in the table.

| Car | Mass (kg) | Speed (m/s) | Acceleration |
|---|---|---|---|
| Ford | 4000 | 10 | 2 |
| Honda | 3000 | 20 | 5 |
| Audi | 2000 | 100 | 0 |

8000 N
15000 N
0 N

i) Force on Ford is largest, force on Honda is smaller, force on Audi is smallest.
ii) Force on Honda is largest, force on Ford is smaller, force on Audi is smallest.
iii) Force on Audi is largest, force on Honda is smaller, force on Ford is smallest.
iv) Force on Ford is largest, force on Audi is smaller, force on Honda is smallest.

/3

## Question 10

A car travels around a corner at a constant speed. Is the net force acting on the car zero or non-zero? Explain your answer.

Non-zero. The change in direction $\Rightarrow$ accel $\neq 0$

Newton's second law.

Net force = mass x accel.

not zero

/3

## Question 11

A ball drops to the surface of the Earth, hits and bounces off. During the time in which the ball is in contact with the Earth, the Earth exerts a force of 100 N on the ball. Which of the following (choose one) is true during the time that the ball is in contact with the Earth?

i) The ball does not exert a force on the Earth.
ii) The ball exerts a force on the Earth and this is less than 100 N.
iii) The ball exerts a force on the Earth and this is exactly 100 N.
iv) The ball exerts a force on the Earth and this is more than 100 N.

Newton's Third Law

/3

## Question 12

A 100 kg skydiver falls directly down toward the surface of the Earth. The skydiver's weight (gravitational force exerted by Earth) is 980 N. The air offers a resistance which amounts to a force of 680 N opposite to the direction in which the skydiver moves. Determine the acceleration of the skydiver.

↑ air = 680N

↓ W = 980N

Net force = mass x accel

980N - 680N = 100kg x accel

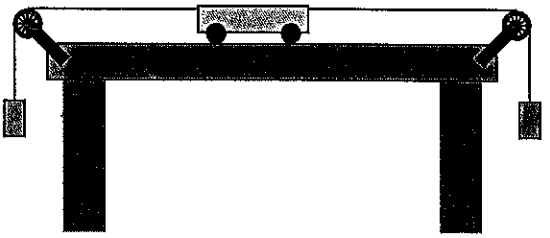
300N = 100kg x accel

accel = $\frac{300N}{100kg}$ = 3.0 m/s²

/5

## Question 13

A cart can slide along a horizontal table. Two suspended mass are attached by strings to the cart. The mass on the right is large than the mass on the left. Consider the possibility that the cart could move left or right. Which of the following (choose one) is true?



speeds up slows down.

i) It is possible that the cart moves right. It is possible that the cart moves left.
ii) It is possible that the cart moves right. It is *not* possible that the cart moves left.
iii) It is *not* possible that the cart moves right. It is possible that the cart moves left.
iv) It is *not* possible that the cart moves right. It is *not* possible that the cart moves left.

/3

## Question 14

A person jumps off a diving board and falls toward a pool. While the person is falling, which of the following is true?

Newton's Third Law

i) The person exerts a force on Earth. The size of this force is the same as the gravitational force exerted by Earth on the person.
ii) The person exerts a force on Earth. The size of this force less than the gravitational force exerted by Earth on the person but it is noticeable.
iii) The person exerts a force on Earth. The size of this force less than the gravitational force exerted by Earth on the person but it is too small to detect.
iv) The person does not exert a force on Earth.

/3