

Concepts of Physics: Test 1

27 September 2024

Name: SOLUTION

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Instructions

- There are 15 questions on 8 pages.
- Show your reasoning and calculations and always explain your answers.

Physical constants and useful formulae

$$\text{speed} = \frac{\text{distance traveled}}{\text{time elapsed}}$$

$$s = \frac{d}{t}$$

$$\text{distance traveled} = \text{speed} \times \text{time elapsed}$$

$$d = st$$

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time elapsed}}$$

$$a = \frac{v}{t}$$

$$\text{distance} = \frac{1}{2} \times \text{acceleration} \times \text{time}^2$$

$$d = \frac{1}{2} \times a \times t^2$$

$$\text{later speed} = \text{earlier speed} + \text{acceleration} \times \text{time}$$

$$v_f = v_i + a \times t$$

$$\text{acceleration} = \frac{\text{net force}}{\text{mass}}$$

$$a = \frac{F}{m}$$

$$\text{net force} = \text{mass} \times \text{acceleration}$$

$$F = ma$$

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

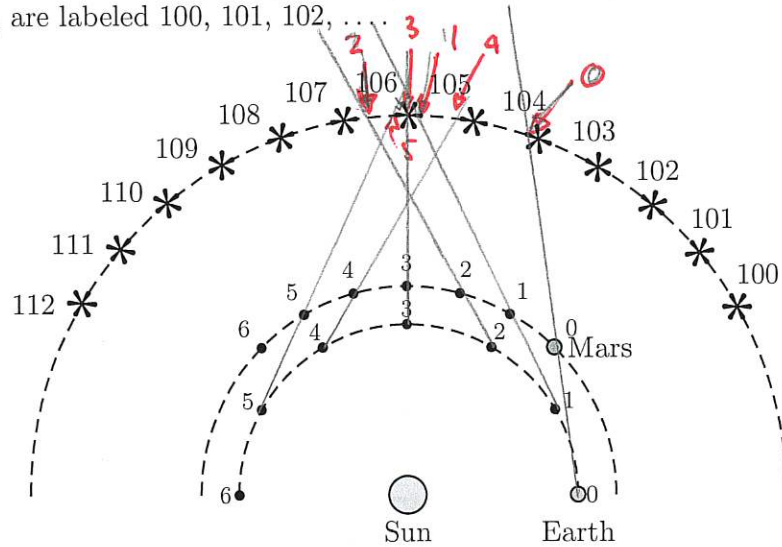
$$F_{\text{grav earth}} = m \times 9.8$$

$$\text{gravitational force} = 6.67 \times 10^{-11} \times \frac{\text{mass}_1 \times \text{mass}_2}{\text{distance}^2}$$

$$F_{\text{grav}} = 6.67 \times 10^{-11} \times \frac{m_1 \times m_2}{d^2}$$

Question 1

Consider a heliocentric model in which Earth and Mars orbit the Sun at different rates (i.e. they take different times to complete one orbit). The diagram indicates their positions at intervals spaced one month apart (month 0, month 1, etc,...). Selected background stars, that are fixed, are labeled 100, 101, 102, ...



Does this model predict that Mars will display retrograde motion when viewed from Earth? If so, during which months will retrograde motion occur? Explain your answers.

Yes. The positions against background stars are illustrated. It appears to move in one direction from 0-1-2, It reverses 2-3-4 retrograde.

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Question 2

The diameter of a quarter is $2.3 \text{ cm} = 0.023 \text{ m}$. A section of North Avenue is about 4.6 km long. Suppose that you laid quarters in a line along this section. Approximately how many quarters would this require? Choose the closest option.

- i) About 5×10^{-6} .
- ii) About 100.
- iii) About 4600.
- iv) About 20000.
- v) About 200000.

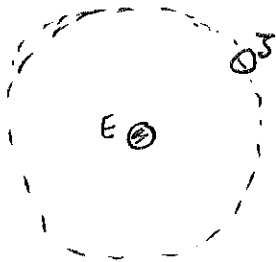
$$\begin{aligned} \text{number quarters} &= \frac{\text{total distance} \checkmark 4600\text{m}}{\text{diameter quarter } 0.023\text{m}} \\ &= \frac{4600}{2.3 \times 10^{-2}} = 2 \times 10^5 \end{aligned}$$

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Question 3

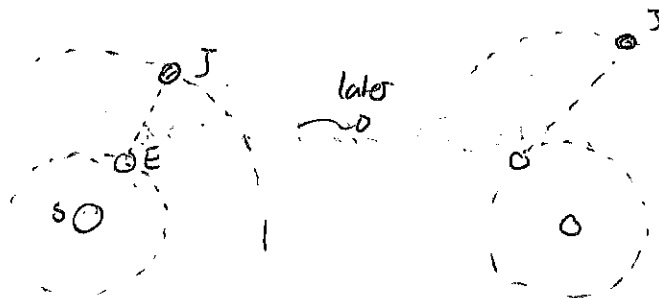
The apparent size (size as viewed from Earth) of the planet Jupiter can be observed while it completes one orbit around the sun. One can consider what two competing models of the solar system would predict for the apparent size.

- a) Consider a **simple geocentric model**, in which all planets orbit in perfect circles centered at Earth. Does this model predict that the apparent size of Jupiter varies or stays constant while Jupiter completes one orbit? *Explain your answer.*



Jupiter will always be same distance from Earth \Rightarrow apparent size will always be same

- b) Consider a **heliocentric model**, in which all planets orbit in perfect circles centered at the Sun. Assume that the time taken for Jupiter to complete one orbit is different to that for Earth to complete one orbit. Does this model predict that the apparent size of Jupiter varies or stays constant while Jupiter completes one orbit? *Explain your answer.*



The distance from Earth to Jupiter will vary with time \Rightarrow apparent size varies

- c) Explain how the apparent size could be used to decide which model is correct. *Note: this is not asking which is correct. It is asking what an observer should do to decide which might be correct.*

Observe apparent size
Does it vary?

Yes

No

Heliocentric correct

Geocentric correct.

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Question 4

Consider

$$\frac{8.0 \times 10^{-5}}{2.0 \times 10^{-3}} = \frac{8.0}{2.0} \times \frac{10^{-5}}{10^{-3}} = 4.0 \times 10^{-5 - (-3)} = 4.0 \times 10^{-2}$$

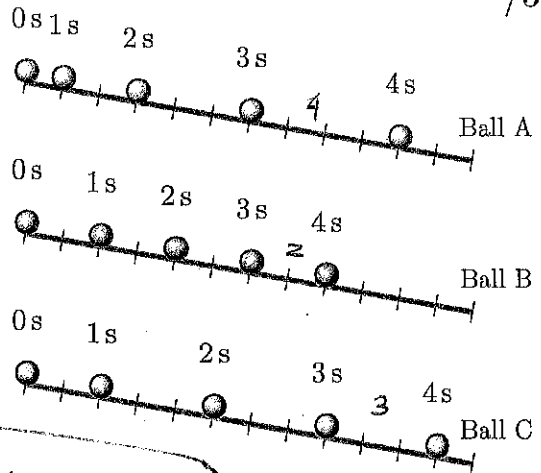
Which of the following (choose one) does this equal?

- i) 4.0×10^{-8}
- ii) 4.0×10^{-2}
- iii) 4.0×10^2
- iv) 16.0×10^{-2}
- v) 16.0×10^2

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Question 5

Various balls slide down sloped surfaces. The position of each is recorded every 1s. The diagram illustrates these.



- a) Which ball has the largest speed between 3.0s to 4.0s? Explain your answer.

Speed = distance/time

A travels largest distance from

3 → 4s

⇒ A largest speed in 3 → 4s

- b) During the interval from 0s to 4s, which ball always has zero acceleration? Explain your answer.

B — it travels same distance per second ⇒ speed constant

- c) During the interval from 0s to 4s, does any ball appear to always have non-zero acceleration? Explain your answer.

A is always speeding up ⇒ A always has non-zero accel

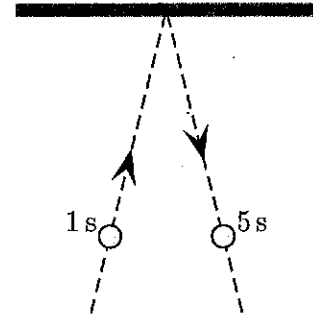
C speeds up from 1 → 2 but has constant speed after ⇒ zero accel 2 → 4s

Only A

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Question 6

A ball rolls along a horizontal table and bounces off a wall at the side of the table. Viewed from above the ball follows the illustrated path. Its positions at 1 s and 5 s are illustrated and the speeds of the ball at those times are equal.



- a) Is the velocity of the ball at 5 s the same as or different to the velocity at 1 s?

No, the directions are different \Rightarrow velocities are different

- b) Is the acceleration of the ball from 1 s to 5 s zero or not? Explain your answer.

It is not zero since velocity at 5s is different to 1s.

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Question 7

During a given interval, that is 5.0 s long, an aircraft speeds up with an acceleration of 15 m/s^2 . At the start of this interval the speed of the aircraft is 100 m/s . Determine the speed of the aircraft at the end of the interval.

$$\begin{aligned} \text{speed later} &= \text{speed earlier} + \text{accel} \times \text{time} \\ &= 100 \text{ m/s} + 15 \text{ m/s}^2 \times 5 \text{ s} \\ &= 100 \text{ m/s} + 75 \text{ m/s} = 175 \text{ m/s} \end{aligned}$$

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Question 8

A snail slithers in a straight line and during a 5 minute interval its speed steadily changes from 0.10 m/s to 0.30 m/s . During the same interval, a wasp flies past in a straight line with constant speed 4.5 m/s . During this interval, which of the following (choose one) is true?

- i) The snail has a larger acceleration than the wasp.
ii) The snail has the same non-zero acceleration as the wasp.
iii) The snail has a smaller acceleration than the wasp.
iv) The snail and the wasp both have zero acceleration.

wasp has zero accel
snail has non-zero

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Question 9

A smooth heavy stone and a lighter hockey puck are placed on the surface of a frozen lake. Each is given a push, by a person, and after this they both move with the same constant speed. After each of the objects leaves the hand which of the following (choose one) is true?

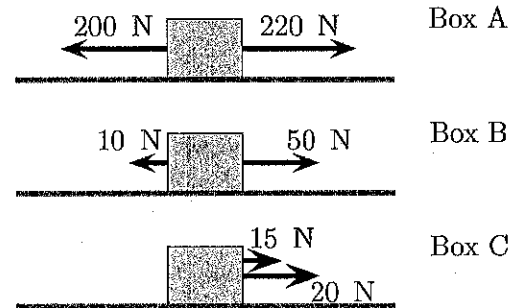
- i) The net force on the stone is larger than that on the puck.
- ii) The net force on the stone is smaller than that on the puck.
- iii) The net forces on each are the same but not zero.
- iv) The net forces on each are zero.

constant speed
 \Rightarrow acceleration = 0
 \Rightarrow net force = 0
 This is true for each.

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Question 10

Various forces act on three identical boxes that can slide along a horizontal frictionless surface. Which box has the largest acceleration? Explain your choice.



$accel = net\ force / mass$

For A net force = $220 - 200 = 20\text{ N}$
 B " " = $50 - 10 = 40\text{ N}$
 C " " = $15 + 20 = 35\text{ N}$

Net force largest on B \Rightarrow B largest accel

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Question 11

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. Velocity changes because direction changes
 \Rightarrow accel \neq 0 \Rightarrow net force non-zero

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Question 12

A snowflake falls vertically down at a constant speed. Which of the following (choose one) is true?

$accel = 0 \Rightarrow net\ force = 0 \Rightarrow$ gravity force down
canceled by upward force.

- i) There is only one force on the snowflake.
- ii) There are two forces on the snowflake, one down and one up. These are equal in size.
- iii) There are two forces on the snowflake, one down and one up. The upward force is larger in size.
- iv) There are two forces on the snowflake, one down and one up. The downward force is larger in size.

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Question 13

A satellite, with mass 1000 kg orbits Earth, with mass 6.0×10^{24} kg, at constant speed in a circular path.

- a) Which of the following (choose one) is true?
 - i) Earth exerts a force on the satellite. The satellite does *not* exert a force on Earth.
 - ii) Earth exerts a force on the satellite. The satellite exerts a force on Earth. This is smaller than the force exerted by Earth on the satellite.
 - iii) Earth exerts a force on the satellite. The satellite exerts a force on Earth. This is larger than the force exerted by Earth on the satellite.
 - iv) Earth exerts a force on the satellite. The satellite exerts a force on Earth. This has the same size as the force exerted by Earth on the satellite.
- b) Explain what type of force the Earth exerts on the satellite.

+3

+1

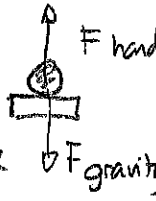
gravitational force

Newton's
Third Law

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Question 14

In both cases net force = 0
 \Rightarrow hand force = gravitational force



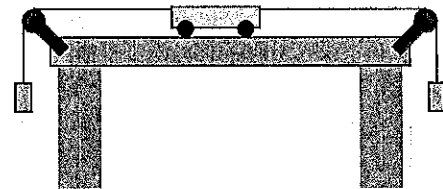
Yuri holds a ball at rest in his hand. Zelda has an identical ball in her hand and raises it vertically at a constant speed. Which of the following is true while these happen?

- a) Which of the following (choose one) is true?
- i) The force exerted by Yuri on the ball is the same as Earth's gravitational force.
 - ii) The force exerted by Yuri on the ball is larger than Earth's gravitational force.
 - iii) The force exerted by Yuri on the ball is smaller than Earth's gravitational force.
- b) Which of the following (choose one) is true?
- i) The force exerted by Zelda on the ball is the same as Earth's gravitational force.
 - ii) The force exerted by Zelda on the ball is larger than Earth's gravitational force.
 - iii) The force exerted by Zelda on the ball is smaller than Earth's gravitational force.

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Question 15

A cart can slide along a horizontal track. Strings are attached to the cart and masses are suspended from them. For a while the cart is observed to move left with constant speed. Ignore friction and air resistance. Which of the following is true while the cart slides left with constant speed?



- i) The force exerted by the string on the left is larger than that exerted by the string on the right.
- ii) The force exerted by the string on the left is smaller than that exerted by the string on the right.
- iii) The force exerted by the string on the left is the same as that exerted by the string on the right.

Explain your choice.

Acceleration = 0 \Rightarrow net force = 0
 \Rightarrow two string forces cancel
 \Rightarrow same force.

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