Concepts of Physics: Test 1

27 September 2022

Name: Solution **Total:** /50

Instructions

- There are 12 questions on 6 pages.
- Show your reasoning and calculations and always explain your answers.

Physical constants and useful formulae

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

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

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

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

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

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

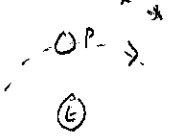
$$\text{gravitational force} = 6.67 \times 10^{-11} \times \frac{\text{mass}_1 \times \text{mass}_2}{\text{distance}^2} \qquad F_{\text{grav}} = 6.67 \times 10^{-11} \times \frac{m_1 \times m_2}{d^2}$$

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.

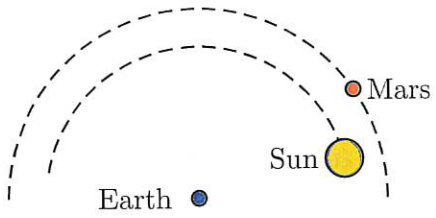
In simple geometric o planet always appears to progress in one direction relative to the background stars. /3



(E)

Question 2

In a geocentric model of the solar system the planets and the Sun orbit at different rates in circles centered at the Earth as illustrated. These circles do not all lie in the same plane (i.e. one can see Mars "over" the Sun and the Sun's light can reach Mars "over" Earth). Mars is observed from the Earth. *According to this model,* which of the following is true regarding the phases of Mars as observed from the Earth?



i) Mars can sometimes appear "full" and sometimes "new."
ii) Mars can sometimes appear "full" but never "new."
iii) Mars never appears "full" and sometimes "new."
iv) Mars never appears "full" nor "new." About half of it is always in view from Earth.

Explain your answer briefly.

A planet can only appear "new" if it is situated between Earth + Sun. This is impossible for Mars.
Mars can appear full

/5

Question 3

A sulfur atom has mass twice that of an oxygen atom. A certain quantity of sulfur dioxide, SO_2, (one molecule consists of two oxygen atoms and one sulfur atom) is completely decomposed into pure oxygen and pure sulfur. Exactly 2.0 kg of oxygen is produced in this process. Determine the mass of sulfur (e.g. 1.0 kg, 2.0 kg, 4.0 kg,...) that is produced in this process.

The mass of oxygen per molecule is exactly equal to the mass of sulfur, since there are two oxygens and each has half the mass of one sulfur.

Thus there will be 2.0 kg of sulfur produced

/3

Question 4

A tire is inflated, reaching a certain pressure. Subsequently more air is added to the tire without any change in the tire's volume or the air temperature. What happens to the pressure in the tire as a result of the additional air (increase, decrease, stay constant)? Explain your answer **using the motion of the air molecules** within the tire.

It increases - pressure measures severity of collisions of molecules with wall and also the frequency with which they occur.

- with more molecules, there are more frequent collisions

=> pressure increases

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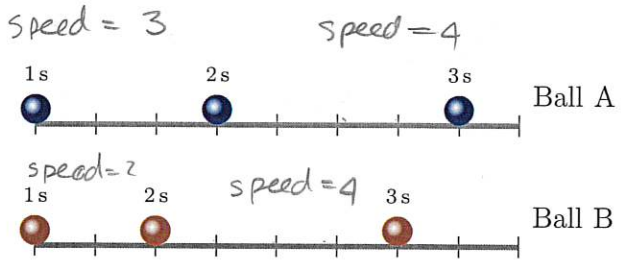
Question 5

Two balls slide along horizontal surfaces. The positions of the balls are recorded at intervals spaced 1s apart. These are illustrated in the diagram.



a) Which of the following (choose one) is true about the speeds of the balls from 2s to 3s?

i) The speed of ball A is the same as the speed of ball B.
ii) The speed of ball A is larger than the speed of ball B.
iii) The speed of ball A is smaller than the speed of ball B.

b) Which of the following (choose one) is true about the speeds of the balls from 1s to 3s?

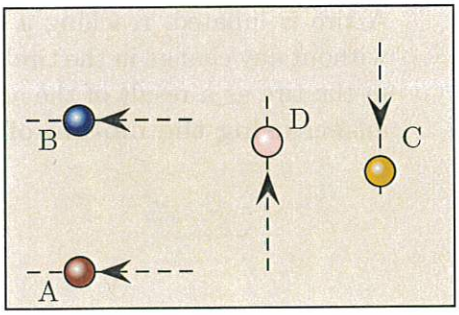
i) The acceleration of ball A is the same as the acceleration of ball B.
ii) The acceleration of ball A is larger than the acceleration of ball B.
iii) The acceleration of ball A is smaller than the acceleration of ball B.

A increases by 1
B increases by 2

/6

Question 6

Several pools balls collide. At some stage after the collision the balls move on the pool table along the illustrated paths. Each ball moves with speed 12.0 m/s. List **all pairs of balls** that have the same velocities as each other. Explain your answer.



velocity is same if
speed is same AND
direction of motion is same.

only A, B have the same direction of motion and speed

⇒ AB only.

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Question 7

A car and a tractor, each travel in a straight line to the right. At an initial moment, the tractor travels with speed 6.0 m/s and the car is at rest. For the next 2.0 s the acceleration of the car is 4.0 m/s^2 while the tractor moves at a constant speed. Determine which is moving faster at the end of this 2.0 s period.

CAR accel = $\frac{\text{change in velocity}}{\text{time}}$

⇒ change in velocity = accel × time

= 4.0 m/s^2 × 2.0 s = 8.0 m/s

TRACTOR velocity constant at 6.0 m/s

⇒ CAR faster.

/6

Question 8

A bee flies in a perfect horizontal circle with constant speed.

a) Explain whether the acceleration of the bee is zero or not.

Non-zero direction changes

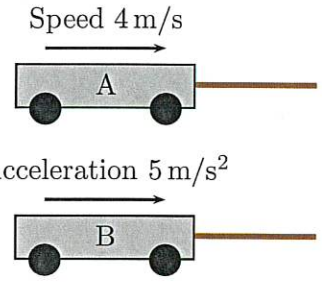
b) Explain whether the net force on the bee is zero or not.

non-zero since net force = mass × accel
not zero not zero

/4

Question 9

Two carts slide in a straight line to the right along a horizontal sheet of ice (there is no friction). There is a string attached to each cart and this string is the only object which could possibly exert a force on each cart. Cart A has mass 5 kg and moves with a constant speed of 4 m/s. Cart B has mass 4 kg and moves with a constant acceleration of 5 m/s^2. Which of the following is true regarding the forces exerted by the strings?



i) The force exerted by the string on cart A is larger than that exerted by the string on cart B.

ii) The force exerted by the string on cart A is smaller than that exerted by the string on cart B.

iii) The force exerted by the string on cart A is the same as that exerted by the string on cart B.

Net force = 0 same as string force
mass × accel.

/3

A accel = 0 ⇒ net force = 0

B net force = 4 kg × 5 m/s^2 = 20 N

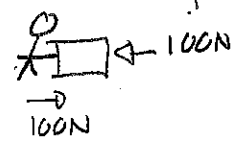
Question 10

You push a 50 kg box across a floor and it moves with constant speed. The force that you exert on the box is 100 N and points in the direction in which the box moves. Is this the only force exerted on the box? Explain your answer.

Net force = mass x accel = 0

= 0

There must be another force to cancel the person force



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Question 11

A 3000 kg aircraft has two engines. Both exert forces in the direction of forward motion of the aircraft. One exerts a 4000 N force and the other a 2000 N force. Determine the acceleration of the aircraft, assuming that there is no air resistance.

net force = 4000 N + 2000 N = 6000 N

$$\text{accel} = \frac{\text{net force}}{\text{mass}} = \frac{6000\text{N}}{3000} = 2.0\text{ m/s}^2$$

/6

Question 12

An astronaut stands on the Moon. The Moon exerts a 120 N gravitational force on the astronaut. Which of the following (choose one) is true?

i) The astronaut does not exert a force on the Moon.
ii) The astronaut exerts a force on the Moon and it is less than 120 N.
iii) The astronaut exerts a force on the Moon and it is exactly 120 N.
iv) The astronaut exerts a force on the Moon and it is more than 120 N.

By Newton's third law, same

/3