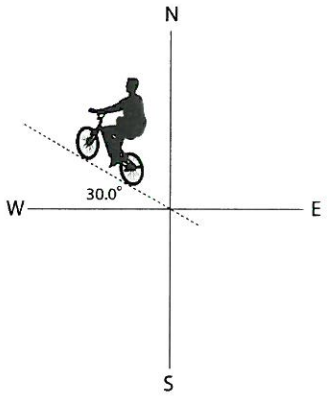
Students	8
Average	26.4/50
Best	49.0/50

12th Physics (2017 – 18)

(1stQ, #1 Mini Test)

Class	No.	Name Solutions



In calculation problems, describe equations clearly and systematically enough to show how to solve the problems.

	$\pi = 3.141593$
Gravitational acceleration rate	$g = 9.80\ m/s^2$
The speed of sound	$V = 331.5 + 0.6t\ [m/s]$ t: ℃
Elementary Charge	$e = 1.60 \times 10^{-19}\ C$
Electron Mass	$m_e = 9.11 \times 10^{-31}\ kg$
Proton Mass	$m_p = 1.673 \times 10^{-27}\ kg$
Coulomb's Law Constant	$k = 8.99 \times 10^{9}\ N \cdot m^2/C^2$
Universal Gravitational Constant	$G = 6.67 \times 10^{-11}\ N \cdot m^2/kg^2$
Avogadro's Number	$N_A = 6.022 \times 10^{23}\ mol^{-1}$
Magnetic Permeability of Free Space	$\mu_0 = 4\pi \times 10\text{-}7\ T \cdot m/A$

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4 pt/question x 13 questions = 52 pt Max 50 pt

／[Total 50 pt]

9/25/2017 *By Tohei Moritani*

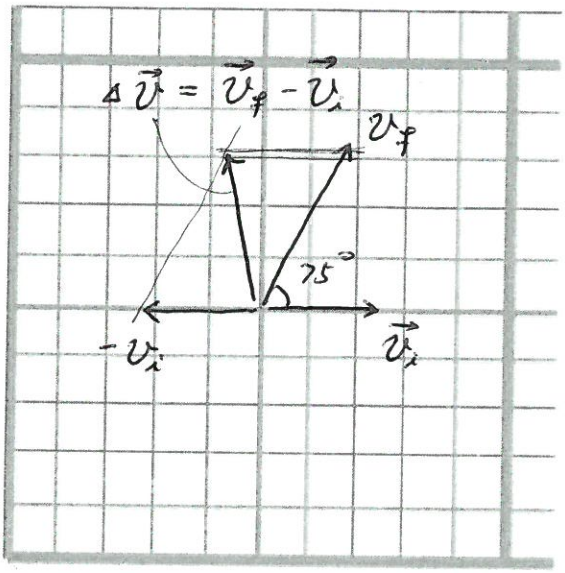
Keio Academy of New York

(Q1) The initial velocity of a car, $\vec{v_i}$, is 45 km/h in the positive direction. The final velocity of the car, $\vec{v_f}$, is 66 km/h in a direction that points 75° above the positive x axis.

(Q1-a) Sketch the vectors, $-\vec{v_i}$, $\vec{v_f}$, and $\Delta\vec{v} = \vec{v_f} - \vec{v_i}$,

(Q1-b) Find the magnitude and direction of the change of the velocity, $\Delta\vec{v}$.

Equations



$$\Delta\vec{v} = \vec{v_f} - \vec{v_i}$$

$$\Delta v_x = v_{fx} - v_{ix} = 66\cos 75° - 45 = -27.9$$

$$\Delta v_y = v_{fy} - v_{iy} = 66\sin 75° = 63.75$$

$$\Delta v = \sqrt{\Delta v_x^2 + \Delta v_y^2} = \sqrt{27.9^2 + 63.75^2}$$

$$= 69.60 \longrightarrow 70 \text{ (km/h)}$$

$$\theta = \tan^{-1}\left(\frac{\Delta v_y}{\Delta v_x}\right) = \tan^{-1}\left(\frac{63.75}{-27.9}\right)$$

$$= -66.36$$

$$180.00° - 66.36° = 113.64°$$

$$\longrightarrow 114°$$

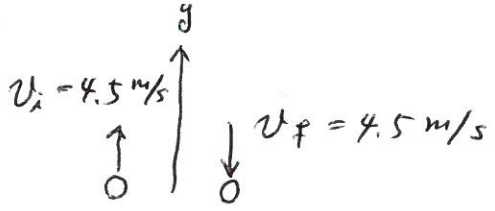
$90.00° - 66.36° = 23.64°$

(Q1-b) Answer
Draw above.
(Q1-b) Answer
70 km/h to the direction of 114°

(73%)

(Q2) You throw a ball upward with an initial speed of 4.5 m/s. When it returns to your hand 0.92 s later, it has the same speed in the downward direction. What was the average acceleration (direction and magnitude) of the ball?

Equations



$$\vec{a} = \frac{\vec{v_f} - \vec{v_i}}{t}$$

$$a_y = \frac{v_{fy} - v_{iy}}{t} = \frac{-4.5 - 4.5}{0.92}$$

$$= \frac{-9.0}{0.92} = -9.78$$

$$\longrightarrow -9.8 \text{ m/s}^2$$

(Q2) Answer
9.8 m/s² downward

(38%)

(Q3) An entertainer is learning to juggle balls thrown very high. One of the balls is thrown vertically upward from 1.88 m above the ground with an initial velocity of 4.90 m/s.
(3-a) When does the ball reach its highest point?
(3-b) If he fails to catch the ball and it hits the ground, how long is it in the air?
Equations

(a) $v = v_0 - gt$, $v = 0$

$$t = \frac{v_0}{g} = \frac{4.90}{9.80} = 0.50000$$

$\longrightarrow 0.500$ (s)

(b) $y = v_0 t - \frac{1}{2} g t^2$

$$-1.88 = 4.90t - \frac{1}{2} \times 9.80\, t^2$$

$$t^2 - t - 0.3837 = 0$$

$$t = \frac{1 \pm \sqrt{1 + 4 \times 0.38367}}{2}$$

$$= 1.296 \longrightarrow 1.30$$

(Q3-a) Answer
0.500 s
(Q3-b) Answer
1.30 s

(56%)

$y' = v_0 t - \frac{1}{2} g t^2$

$= 4.90 \times 0.5 + \frac{1}{2}(-9.80) \times 0.5^2$

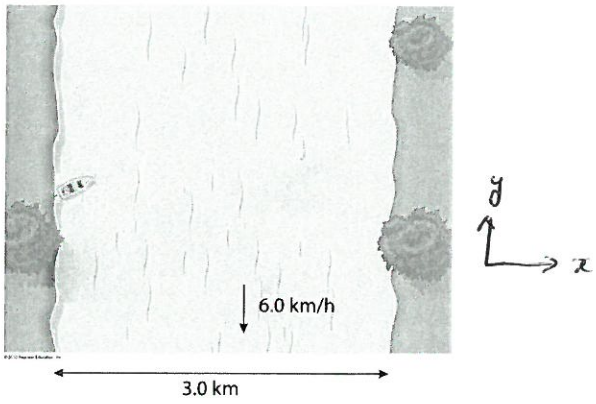
$= 1.225$

$1.225 + 1.88 = 3.105$

$t = \sqrt{\frac{3.105}{9.80}} = 0.7960$

$0.7960 + 0.5000 = 1.2960$

(Q4~7) A boat is moving at 15 km/h relative to the water is crossing a river 3.0 km wide in which the current is flowing at 6.0 km/h.
(Q4) In what direction should it head in order to get across the river in the shortest possible time, and how many minutes will it take?
(Q5) Where will it arrive at in case (Q4)?
(Q6) In what direction should the boat head if it is to reach a point on the other shore directly opposite to the starting point?
(Q7) How many minutes will the crossing take in case (6)?
Equation



(Q4) $t = \frac{d}{v} = \frac{3.0}{15} = 0.200 \rightarrow 0.20\ h$

(Q5) $d' = v't = 6.0 \times 0.200 = 1.200 \rightarrow 1.2$ km

(Q6) $\vec{v}_{BW} = \vec{v}_{BG} + \vec{v}_{GW} = \vec{v}_{BG} - \vec{v}_{WG}$

$v_{BWx} = v_{BGx} - v_{WGx} = v_{BGx} - 0 = v_{BGx}$

$v_{BWy} = v_{BGy} - v_{WGy} = 0 - (-6.0) = 6.0$

$v_{BWy} = 6.0$, $v_{BW} = 15$, v_{BWx}, θ

$\sin\theta = \frac{6.0}{15}$

$\theta = \sin^{-1}\left(\frac{6.0}{15}\right) = 23.6^\circ \rightarrow 24^\circ$

(Q7) $v_{BWx} = \sqrt{v_{BW}^2 - v_{BWy}^2} = \sqrt{15^2 - 6.0^2}$

$= 13.7$

$v_{BGx} = v_{BWx} = 13.7$ (km/h)

$t'' = \frac{d}{v_{BGx}} = \frac{3.0}{13.7} = 0.218$ 13.08 min

$\rightarrow 0.22$ (h)

13 min

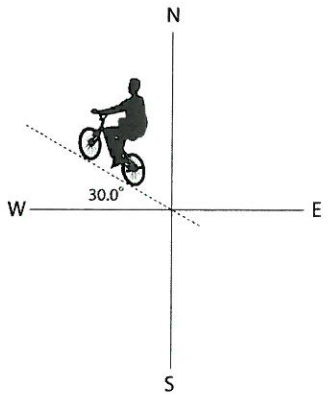
(Q4) Answer
Perpendicular to the shore
0.20 h
or 12 min
(39%)

(Q5) Answer
1.2 km downstream
in the opposite shore
(41%)

(Q6) Answer
24° upstream
(48%)

(Q7) Answer
0.22 h
or 13 min
(50%)

(Q8) You are riding a bike 30.0° north of west at a speed of 10.0 m/s. You feel that wind is coming from the northeast at 6.0 m/s. Find the speed and direction of the wind in reference to the ground?



Equation

$v_{BG} = 10\ m/s$

$v_{BGx} = -10\cos 30^\circ, \quad v_{BGy} = 10\sin 30^\circ$

$v_{WBx} = -6\cos 45^\circ, \quad v_{WBy} = -6\sin 45^\circ$

$\vec{v}_{WG} = \vec{v}_{WB} + \vec{v}_{BG}$

$v_{WGx} = v_{WBx} + v_{BGx} = -6\cos 45^\circ - 10\cos 30^\circ = -4.24 - 8.66$

$= -12.903$ (3sf)

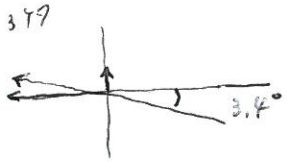
$v_{WGy} = v_{WBy} + v_{BGy} = -6\sin 45^\circ + 10\sin 30^\circ = -4.24 + 5.000$

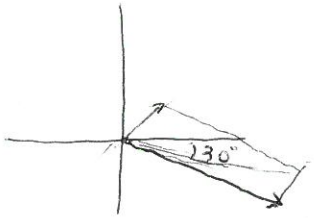
$= 0.757$ (3sf)

$v_{WG} = \sqrt{v_{WGx}^2 + v_{WGy}^2} = \sqrt{12.903^2 + 0.757^2} = 12.9251 \rightarrow 12.9\ m/s$ (3sf)

$\sqrt{167.18 + 0.573} \rightarrow \sqrt{167.8} =$

$\theta = \tan^{-1}\left(\frac{v_{WGy}}{v_{WGx}}\right) = \tan^{-1}\left(\frac{0.757}{-12.925}\right) = -3.352 \rightarrow -3^\circ$ (1sf)





(Q8) Answer

12.9 m/s

from ~~3.4°~~ 3° South of east

(61%)

(Q9) A merry-go-round makes 24 revolutions in a 3.0-min ride.
(Q9-a) What is its average angular speed in rad/s?
(Q9-b) What is the tangential speed of a person 4.0 m from the center, or axis of rotation.

(a)

$$\frac{24\ rev}{3\ min} = \frac{24 \times 2\pi\ rad}{3 \times 60\ s}$$

$$= \frac{15\ rad}{180\ s}$$

$$= 0.8379\ (rad/s)$$

$$\longrightarrow 0.84\ (rad/s)$$

(b)

$$v = r\omega$$

$$= 4.0 \times 0.8379$$

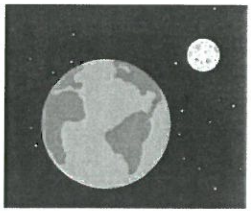
$$= 3.359$$

$$\longrightarrow 3.4\ m/s$$

(Q9-a) Answer 0.84 rad/s
(Q9-a) Answer 3.4 m/s

(70%)

(Q10) The Moon revolves around the Earth in 27.3 days in a nearly circular orbit with a radius of 3.8 x10^5 km. Assuming that the Moon's orbital motion is a uniform circular motion, what is the Moon's acceleration as it "falls" toward the Earth?



Equations

$$\frac{1\ rev}{27.3\ day} = \frac{2\pi\ rad}{27.3 \times 24 \times 3.6 \times 10^3\ s}$$

$$= 2.66 \times 10^{-6}\ rad/s$$

$$a = r\omega^2$$

$$= (3.8 \times 10^5 \times 10^3\ m) \times (2.66 \times 10^{-6}\ rad/s)^2$$

$$= 26.94 \times 10^{8-12}\ m/s^2$$

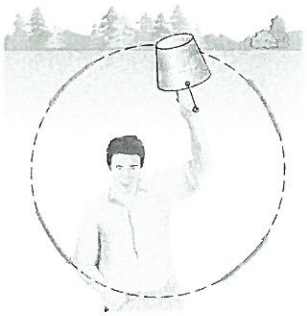
$$= 2.694 \times 10^{8-12+1}$$

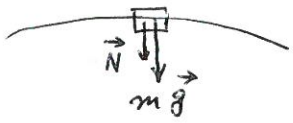
$$\longrightarrow 2.7 \times 10^{-3}\ m/s^2$$

(Q10) Answer

$2.7 \times 10^{-3}\ m/s^2$ (27%)

(Q11, 12) A student is to swing a bucket of 1.0 kg water in a vertical circle without spilling any, as shown in the figure. The distance from his shoulder to the center of mass of water is 1.0 m.
(Q11) What is the minimum speed required to keep the water from coming out of the bucket at the top of the swing?
(Q12) Find the direction and magnitude of the centrifugal force acting on the water at the top of the swing.
Equations





$$-N - mg = -m\frac{v^2}{r}, \quad N = 0$$

$$v = \sqrt{gr}$$

$$= \sqrt{9.80 \times 1.0}$$

$$= 3.13 \longrightarrow 3.1 \ (m/s)$$

$$F = m\frac{v^2}{r}$$

$$= 1.0 \times \frac{(3.13)^2}{1.0} = 9.797 \longrightarrow 9.8 \ (N)$$

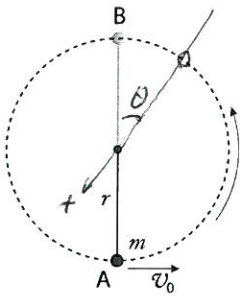
(Q11) Answer

3.1 m/s (95%)

(Q12) Answer

9.8 N upward (58%)

(Q13) An m [kg] mass suspended with an r [m] string from a peg is given an initial velocity v_0 [m/s] horizontally. Find the least initial velocity v_0 so that the ball can reach the top of the loop without loosening the string.
Equations



$$T + mg\cos\theta = m\frac{v^2}{r} \quad -①$$

$T = 0$
$\theta = 0$ } $-②$

①, ② $\rightarrow$ $g = \frac{v^2}{r}$ $-③$

$$\frac{1}{2}mv_0^2 = mg(2r) + \frac{1}{2}mv^2 \quad -④$$

④ $\rightarrow$ $v_0^2 = 4gr + v^2$ $-⑤$

③ and ⑤ $v_0^2 = 4gr + gr = 5gr$

$$v_0 = \sqrt{5gr}$$

(Q12) Answer $\sqrt{5gr}$ (25%)

Your opinions

The solution will be shown on the Website of Physic Class tonight.