PHYS 101 Midterm examination #1 (vers. 1A)

18 Oct., 2002 Name Key

Time: 50 minutes Student No.

For questions 2 and 3, please show complete solutions and explain your reasoning, stating any principles that you have used.

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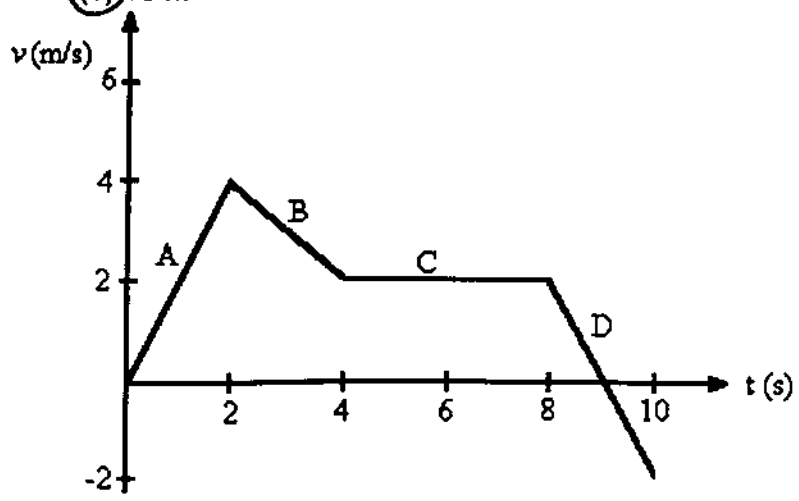
1 (10 marks). For each of the following five questions, please circle one answer only.

(e) (i) The figure below shows the velocity-versus-time graph for a robot. Find the displacement of the robot for the 10 s shown on the graph.

(a) 4 m
(b) 2 m
(c) 16 m
(d) 20 m
(e) 18 m

Area $= 19 - 1 = 18$ m



(b) (ii) A golf ball of mass 46 g is struck by a club and flies off at 50 m/s. If the head of the club was in contact with the ball for 0.60 ms, what was the average force on the ball during the impact (Note: 1 ms = 1 x 10^{-3} s)?

(a) 1.4 kN
(b) 3.8 kN
(c) 1.4 N
(d) 3.8 N
(e) 3.8 x 10^6 N

$\vec{F}_{ave} \cdot \Delta t = \Delta \vec{p}$

$$F_{ave} = \frac{\Delta p}{\Delta t} = \frac{(0.046\,kg)(50\,m/s)}{6 \times 10^{-4}\,s} = 3.8 \times 10^3\,N$$

(d) (iii) When a parachutist jumps from an airplane, he eventually reaches a constant speed, called the terminal velocity. This means that

(a) the acceleration is equal to g
(b) the force of air resistance is equal to zero
(c) the effect of gravity has died down
(d) the magnitude of the drag force is equal to the weight of the parachutist
(e) there is no gravity acting on the parachutist

$$\left.\begin{array}{l}\vec{v} = const \\ \vec{a} = 0\end{array}\right\} \Rightarrow \vec{F}_{drag} + m\vec{g} = 0$$

$$\vec{F}_{drag} = -m\vec{g} \Rightarrow F_{drag} = mg$$

(a) (iv) A constant force is applied to an object that causes a certain displacement. If the angle between the force and the displacement is 135°. The work done by this force is

(a) negative
(b) positive
(c) 0
(d) varying from negative to positive
(e) varying from positive to negative

$W = \vec{F} \cdot \Delta\vec{x} = |F| \cdot |\Delta x| \cdot \cos\theta$

$\cos 135° < 0 \Rightarrow W < 0$

(b) (v) Two points, A and B, are on a disk that rotates about an axis. Point A is three times as far from the axis as point B. If the speed of point B is v, what is the speed of point A?

(a) v
(b) 3v
(c) v/3
(d) 9v
(e) $\sqrt{3}$ v

$v = r_B \cdot \omega$.

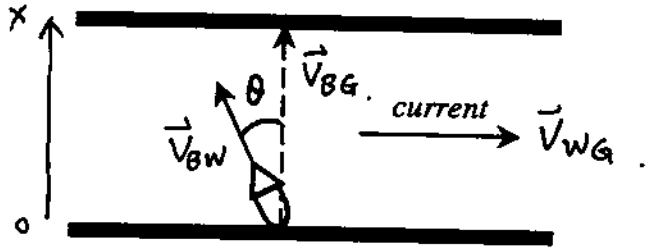
$v_A = r_A \cdot \omega = 3 \cdot r_B \cdot \omega = 3v$.

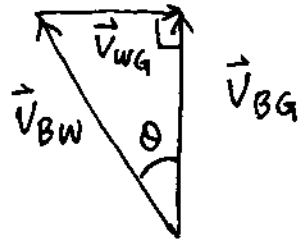
2 (4 marks). A river is 1.2 km wide and its current is flowing at 3 km/h. A man wants to drive a boat across the river to reach a point on the other bank directly opposite to his starting point. His boat is capable of travelling 5 km/h in still water.

A) At what angle upstream should the man point his boat?
B) How long does it take for him to cross the river?

[Solution]:

A). $\vec{V}_{BG} = \vec{V}_{BW} + \vec{V}_{WG}$.





$V_{WG} = 3$ km/h.

$V_{BW} = 5$ km/h.

$\sin\theta = \frac{|\vec{V}_{WG}|}{|\vec{V}_{BW}|} = \frac{3 \text{ km/h}}{5 \text{ km/h}} = 0.6$.

$\therefore \theta = \sin^{-1} 0.6 = 36.9°$

B). $V_{BG} = \sqrt{V_{BW}^2 - V_{WG}^2} = \sqrt{(5 \text{ km/h})^2 - (3 \text{ km/h})^2} = 4$ km/h.

$\Delta t = \frac{\Delta x}{V_{BG}} = \frac{1.2 \text{ km}}{4 \text{ km/h}} = 0.3 \text{ h} = 18 \text{ min}$.

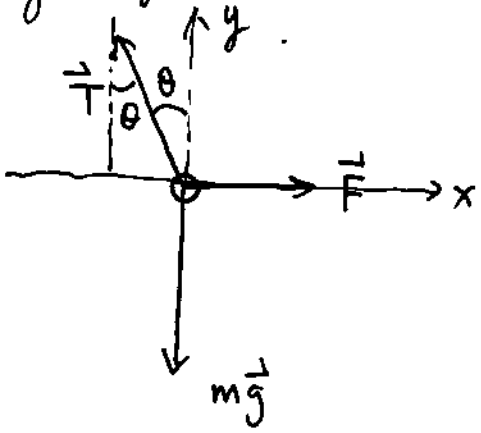
3(6 marks). In the diagram below, a ball hangs from the ceiling. The length of the string is 1.4m. A horizontal force, F, holds the ball steady. Given F = 8.2 N and θ = 25°.

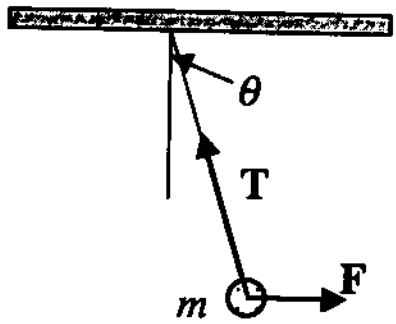
A) Find the mass of the ball.

B) If the ball is released (F=0), what will be the speed of the ball when it reaches the bottom?

[Solution]:

A). Free-Body diagram.





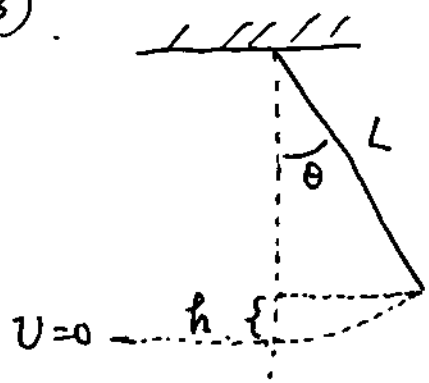
$\vec{F}_{Net} = m\vec{a} = 0$. ($\because \vec{a} = 0$).

$$\therefore \begin{cases} F - T\sin\theta = 0 \\ T\cos\theta - mg = 0 \end{cases} \Rightarrow T = \frac{F}{\sin\theta}.$$

$$m = \frac{T\cdot\cos\theta}{g} = \frac{F\cdot\cos\theta}{g\sin\theta}.$$

i.e., $m = \dfrac{(8.2\,N)\cos 25^\circ}{(9.81\,m/s^2)\cdot\sin 25^\circ} = 1.79\ kg \approx 1.8\ kg$.

B).



$h = L - L\cdot\cos\theta = L(1-\cos\theta)$.

Conservation of Mechanical Energy:

$\Delta E = 0$. OR. $E_i = E_f$.

$mgh = \frac{1}{2}mv^2$.

$v = \sqrt{2gh} = \sqrt{2gL(1-\cos\theta)}$

$= \sqrt{2(9.81)(1.4)(1-\cos 25^\circ)} = 1.60\ m/s$.