Kuwait University **Physics Department**

Physics 101
First Midterm Examination
Tuesday, March 12, 2002
5-7 PM

Student's Name: ....الحل النموذجي.... Student's Number: ....

Instructor's Name:........................

Dr. Abdulnasser **Abu-Rezq**, Dr. Adnan **Al-Yaseen**
Dr. Ahmad **Al-Jassar**, Dr. Ahmad **Tolba**,
Dr. Afeefa **Behbehani**, Dr. Hassan **Raafat**
Dr. Ismail **Saleh** , Dr. Majid **Fahmy**, Dr. Yacob **Makdisi**.

For use by instructors only

Problem	1	2	3	4	5	6	7	8	9	10	Total
Points											

Notes

1. Answer all questions
2. Each question will be assigned 2 points
3. The solution should be given explicitly for each problem
4. No solution = no points
5. Check the correct answer for each question
6. Take g = 10 m/s^2

1. An object moves along a straight line with velocity $v(t) = (98 - 2t^2)$ m/s. When the object momentarily stops its acceleration is

(a) 0 m/s^2 (b) -4.0 m/s^2 (c) -9.8 m/s^2 $\boxed{\text{(d) } -28\ m/s^2}$ (e) other

Solution

when the object is changing its velocity direction

$v(t) = 0$

$\therefore 2t^2 = 98 \Rightarrow t = 7\ s$

The object will accelerate at this moment as follow

$\therefore a(t) = \frac{dv}{dt} = -4t$

$\therefore a(7) = -4(7) = \underline{-28\ m/s^2}$ #

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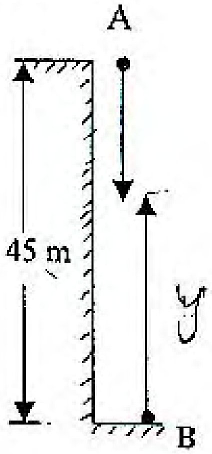
2. An object A is released from the top of a bridge, which is 45 m high above the ground. At the same time, another object B is thrown vertically upward from the ground with initial velocity $v_o = 15$ m/s. Both objects A and B will meet in the air after

(a) 9 s (b) 15 s $\boxed{\text{(c) 3 s}}$ (d) 45 s (e) other

Solution



for object A $\Delta y = \cancel{v_o t} - \frac{1}{2}gt^2$

$\Rightarrow -(45-y) = -\frac{1}{2}gt^2$

$\Rightarrow y = 45 - \frac{1}{2}gt^2$ ------ (1)

for object B

$y = 15.t - \frac{1}{2}gt^2$ ------ (2)

now eqn (1) = (2)

$\therefore 15t - \cancel{\frac{1}{2}gt^2} = 45 - \cancel{\frac{1}{2}gt^2}$

$15t = 45$

$\underline{t = 3\ s}$ #

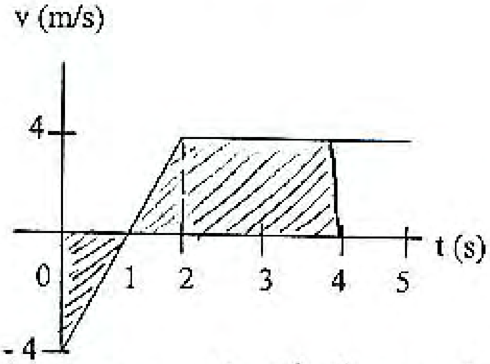
Note:

Both objects will meet at the ground after the second object return back.

3. The velocity-time graph for an object that is moving along the x-axis is shown in the figure. The total distance covered by the object during the first 4 seconds is

(a) 16 m (b) 12 m (c) 24 m (d) 22 m (e) other

Solution



- To determine the distance we have to calculate the areas under the curve.
- All distances are added regardless of the direction because we are calculating distance not displacement.

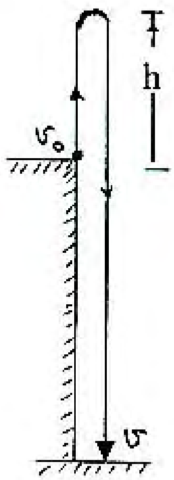
$$D = \tfrac{1}{2}(4)(1) + \tfrac{1}{2}(4)(1) + (4)(2) -$$

$$= 12 \text{ m} \quad \#$$

4. A stone is thrown vertically upward by an astronaut on the surface of the moon with a velocity of 5 m/s. After 10 seconds it has a downward velocity of 11 m/s. What is the maximum height of the stone (h).
[Hint: First calculate the acceleration due to gravity on the moon.]

(a) 7.8 m (b) 20.8 m (c) –7.8 m (d) –20.8 m (e) other

Solution



The gravity on the moon is not the same as it is on the earth.

From the first rule $v_f = v_0 - g_m t$

$\Rightarrow \quad -11 = 5 - g_m (10)$

$\Rightarrow \quad g_m = 1.6 \ m/s^2$

now $v_f^2 = v_0^2 - 2g\,\Delta y$

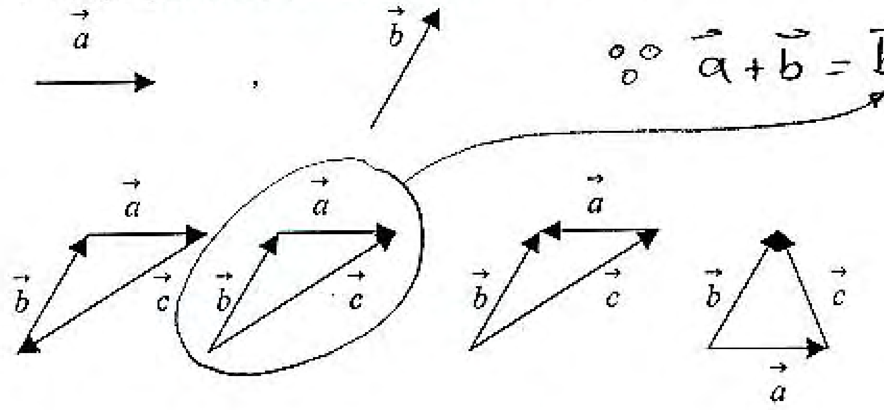
at maximum height $v_f = 0$

$\therefore \quad 0 = (5)^2 - 2(1.6)\,h$

$25 = 3.2\,h$

$h = \dfrac{25}{3.2} = 7.8 \text{ meters} \quad \#$

5. In the figure, which of the indicated methods for adding the vectors $\vec{a}$ and $\vec{b}$ are proper to determine the vector $\vec{c} = \vec{a} + \vec{b}$



$\therefore \vec{a} + \vec{b} = \vec{b} + \vec{a}$

(a) (b) (c) (d)

Solution

(a) (b) (c) (d) (e) other

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6. The figure shows two vectors $\vec{a}$ and $\vec{b}$. If their magnitudes are a = 10 m and b = 5 m. The resultant vector $\vec{c} = \vec{a} + \vec{b}$ is

(a) $13\hat{i} + 2.5\hat{j}$ $\boxed{\text{(b) } 4.33\hat{i} - 7.5\hat{j}}$ (c) $-13\hat{i} + 2.5\hat{j}$ (d) $-4.33\hat{i} - 7.5\hat{j}$ (e) other

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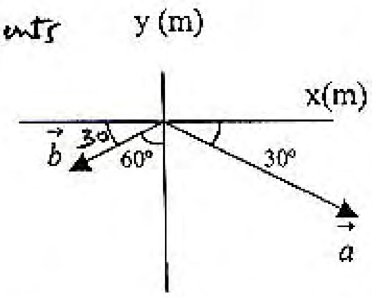
Solution

resolve $\vec{a}$ and $\vec{b}$ to their components



$\vec{a} = 10\cos(30)\hat{i} - 10\sin(30)\hat{j}$

$= 8.66\,\hat{i} - 5\,\hat{j}$

$\vec{b} = -5\cos(30)\hat{i} - 5\sin(30)\hat{j}$

$= -4.33\,\hat{i} - 2.5\,\hat{j}$

$\vec{a} + \vec{b} = (8.66 - 4.33)\hat{i} + (-5 - 2.5)\hat{j}$

$= 4.33\,\hat{i} - 7.5\,\hat{j}$ //

$\vec{a}$ in the fourth quarter

$\vec{b}$ in the third quarter

7. If $\vec{a}=2\hat{i}+3\hat{j}-4\hat{k}$, $\vec{b}=-3\hat{i}+4\hat{j}+2\hat{k}$ and $\vec{c}=7\hat{i}-8\hat{j}$ then $(3\vec{a}\times\vec{b}).2\vec{c}$ is

(a) 540 $\hat{j}$ (b) 540 $\hat{i}$ (c) 580 (d) 270 $\hat{i}$ (e) other

Solution

$\rightarrow 3\vec{a} = 6\hat{i}+9\hat{j}-12\hat{k}$

$$\rightarrow (3\vec{a}\times\vec{b}) = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 6 & 9 & -12 \\ -3 & 4 & 2 \end{vmatrix} = (18+48)\hat{i}+(36-12)\hat{j}+(24+27)\hat{k}$$

$$= 66\hat{i}+24\hat{j}+51\hat{k}$$

$$\rightarrow (3\vec{a}\times\vec{b}).2\vec{c} = (66\hat{i}+24\hat{j}+51\hat{k}).(14\hat{i}-16\hat{j})$$

$$= 66(14)-24(16)+0 = 924-384$$

$$= \underline{540}$$

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8. The motion of an object in the x-y plane is described by the position vector $\vec{r}=16t^2\hat{i}+(t^3-12t)\hat{j}$, where r is in meters and t is in seconds. The object's speed when it reaches the maximum displacement in the y direction is

(a) -16 m/s (b) 32 m/s $\boxed{\text{(c) 64 m/s}}$ (d) -32 m/s (e) other

Solution

$\vec{r} = 16t^2\hat{i}+(t^3-12t)\hat{j}$

maximum displacement in the y-component is

$$\frac{d\vec{r}_y}{dt} = 0 \Rightarrow \frac{d}{dt}(t^3-12t) = 0$$

$$\therefore 3t^2-12=0 \Rightarrow t = \underline{2\,s}$$

at this moment $v_y=0$, and only v_x has a value.

$$v = v_x + v_y = v_x + 0$$

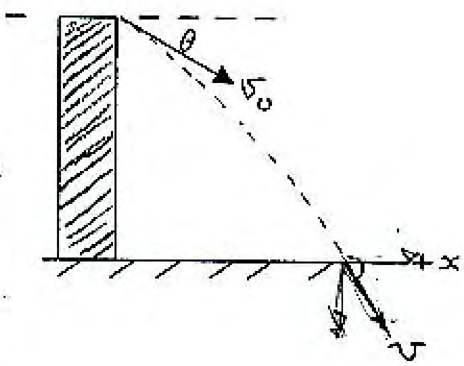
$$v_x = \frac{dr_x}{dt} = 32t \Rightarrow v_x(2) = 32(2) = \underline{64\,m/s}$$

9. **A ball is thrown from the roof of a 100 m tall building with a speed of 30 m/s at an angle $\theta = 30°$ below the horizontal. In what direction does the ball hit the ground?**

[Hint: Find the direction of the velocity relative to the positive x-axis just before hitting the ground].

(a) -119° **$\boxed{\text{(b) -61°}}$** **(c) -29°** **(d) 119°** **(e) other**

Solution



$\because \Delta y = -100 m \Rightarrow v_y^2 = v_{oy}^2 - 2g\Delta y$

$= (-30 \sin 30)^2 - 2(10)(-100)$

$= 2225\ m$

$\therefore v_y = \sqrt{2225} = \pm 47.17\ m/s$

we take only the negative value.

$-47.18\ m/s$

now $v = v_x \hat{i} + v_y \hat{j} = v_{ox} \hat{i} + v_y \hat{j} = (30 \cos 30)\hat{i} - 47.18 \hat{j}$

$= 25.98 \hat{i} - 47.18 \hat{j}$

$\theta = \tan^{-1}\left(\frac{v_y}{v_x}\right) = \tan^{-1}\left(-\frac{47.18}{25.98}\right) = -61.5°$

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10. **A projectile is thrown from the ground with an initial velocity $\vec{v} = 86.6\hat{i} + 50\hat{j}$ m/s. What is its horizontal range?**

(a) 500 m **(b) 250 m** **$\boxed{\text{(c) 866 m}}$** **(d) 750 m** **(e) other**

Solution

$\vec{v} = 86.6\hat{i} + 50\hat{j}\ m/s$

$v_0 = \sqrt{(86.6)^2 + (50)^2} \simeq 100$

$\theta = \tan^{-1}\left(\frac{50}{86.6}\right) = 30°$

$R = \frac{v_0^2 \sin 2\theta_0}{g} = \frac{(100)^2 \sin 60}{10} = \frac{10000(.866)}{10} = 866 m$