Name__________________________

Feb 13, 2001

Phys 121 — Spring 2001
Exam #1

1.	____________	(5)
2.	____________	(10)
3.	____________	(8)
4.	____________	(9)
5.	____________	(22)
6.	____________	(12)
7.	____________	(14)
MC	____________	(20)
Total	____________	(100)

You must show all your work and include the right units with your answers!

$$A_x = A\cos\theta \qquad A_y = A\sin\theta \qquad A = \sqrt{A_x^2 + A_y^2} \qquad \theta = \tan^{-1}\left(\frac{A_y}{A_x}\right)$$

$$1\,\text{m} = 100\,\text{cm} \qquad 1\,\text{km} = 1000\,\text{m} \qquad 1\,\text{kg} = 10^3\,\text{g} \qquad g = 9.80\,\tfrac{\text{m}}{\text{s}^2}$$

$$1\,\text{N} = 1\,\tfrac{\text{kg}\cdot\text{m}}{\text{s}^2} \qquad 1\,\text{N} = 0.2248\,\text{lb} \qquad G = 6.67\times10^{-11}\,\tfrac{\text{N}\cdot\text{m}^2}{\text{kg}^2} = 6.67\times10^{-11}\,\tfrac{\text{m}^3}{\text{kg}\cdot\text{s}^2}$$

$$v_x = v_{0x} + a_x t \qquad x = v_{0x}t + \tfrac{1}{2}a_x t^2 \qquad v_x^2 = v_{0x}^2 + 2a_x x \qquad x = \tfrac{1}{2}(v_{0x} + v_x)t$$

$$v_y = v_{0y} + a_y t \qquad y = v_{0y}t + \tfrac{1}{2}a_y t^2 \qquad v_y^2 = v_{0y}^2 + 2a_y y \qquad y = \tfrac{1}{2}(v_{0y} + v_y)t$$

$$R = \frac{2v_0^2\sin\theta\cos\theta}{g} = \frac{v_0^2\sin 2\theta}{g}$$

$$\mathbf{F}_{\text{net}} = m\mathbf{a} \implies F_{\text{net},\,x} = ma_x \qquad F_{\text{net},\,y} = ma_y$$

$$F_{\text{grav}} = G\frac{m_1 m_2}{r^2} \qquad g_{\text{planet}} = G\frac{M}{R^2}$$

Multiple Choice

1. How many cubic meters (m^3) are there in one cubic kilometer (km^3)?

a) 10^2
b) 10^3
c) 10^6
d) 10^9

2. If ρ is a *density* (i.e. mass per volume) and v is a *speed* then the MKS units of the quantity $\frac{1}{2}\rho v^2$ are:

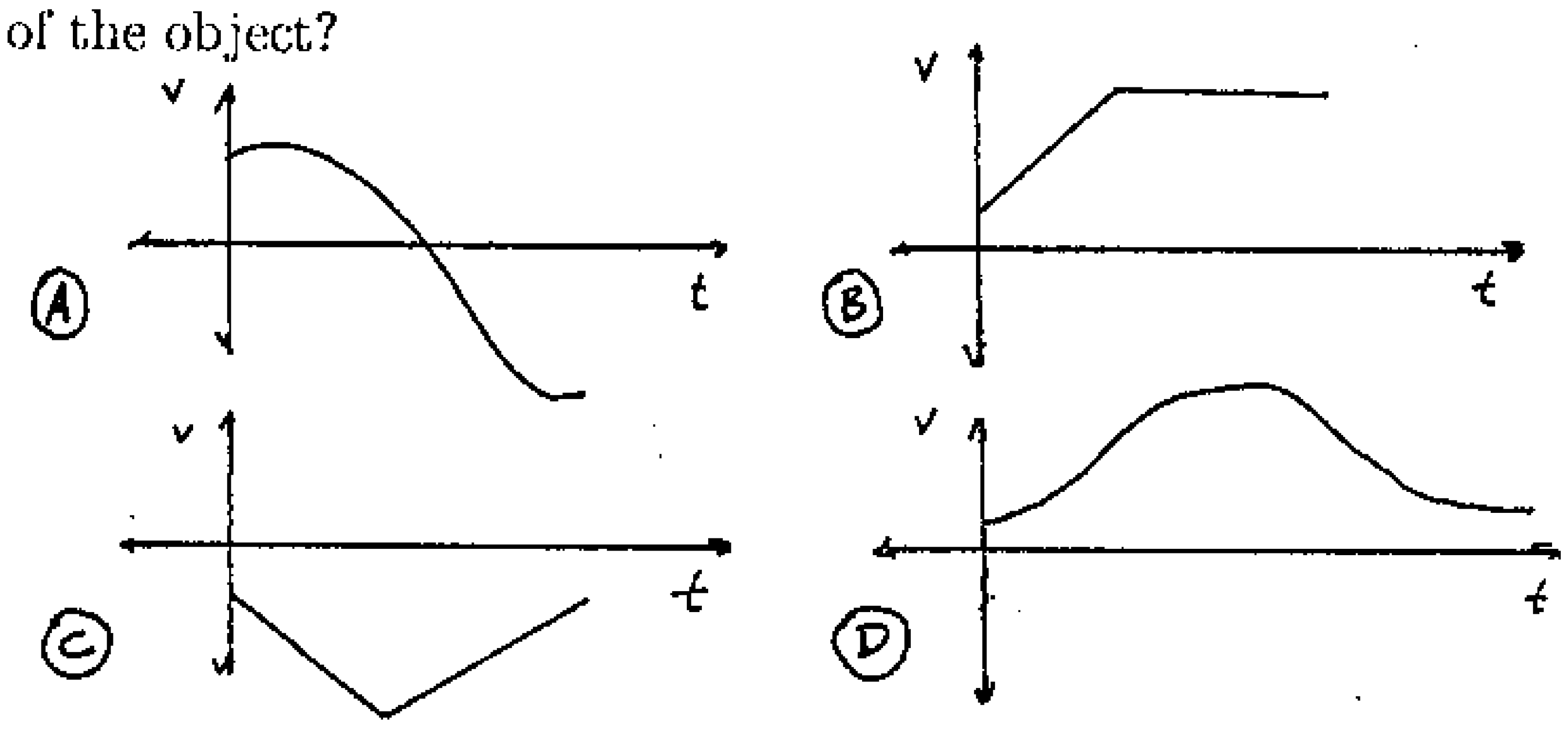
a) $\frac{\text{kg}}{\text{m}^2\cdot\text{s}}$
b) $\frac{\text{kg}}{\text{m}^2\cdot\text{s}^2}$
c) $\frac{\text{kg}}{\text{m}\cdot\text{s}^2}$
d) $\frac{\text{kg}\cdot\text{m}^2}{\text{s}^2}$

3. Ball A is shot upward from ground level with an initial speed v_0; it attains a maximum height H. Ball B is shot upward from ground level with initial speed $3v_0$. It attains a maximum height of

a) $\sqrt{3}H$
b) $3H$
c) $9H$
d) It is impossible to say without knowing the value of v_0.

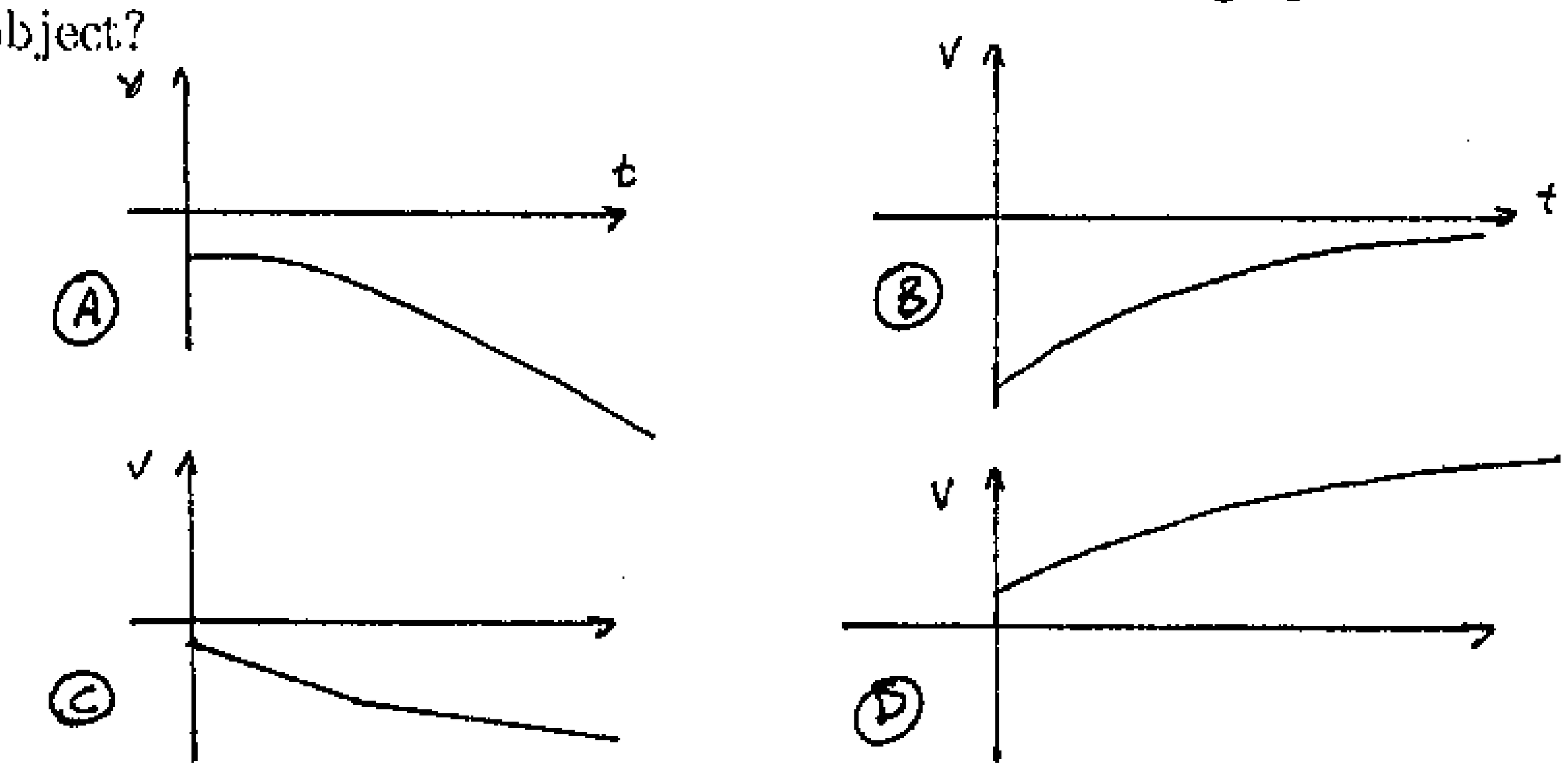
4. An object moving in one dimension reverses its direction of motion. Which one of the v vs. t curves shown here gives the motion of the object?

a) A
b) B
c) C
d) D

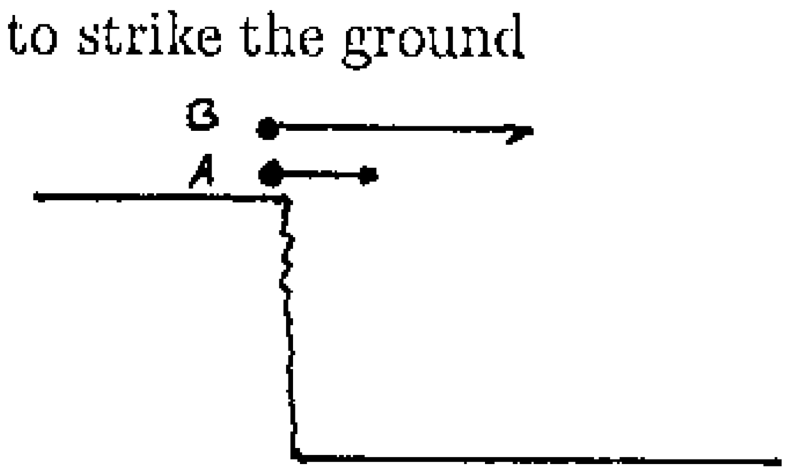


5. An object moving in one dimension is decreasing its speed. Which one of the v vs. t graphs shown here gives the motion of the object?

a) A
b) B
c) C
d) D



6. Rocks A and B are both projected horizontally off the top of a cliff. The initial speed of rock B is 3 times that of rock A. Compared to rock A, the time it takes B to strike the ground below is



a) $\frac{1}{3}$ as long.
b) The same.
c) 3 times as long.
d) 9 times as long.

7. (Continuation of 6) When rock B strikes the ground below, the horizontal distance it has travelled, as compared with rock A is

a) The same.
b) $\sqrt{3}$ times as long.
c) 3 times as long.
d) 9 times as long.

8. (Continuation of 6) As compared with rock A, the magnitude of the acceleration of rock B is

a) $\frac{1}{3}$ as large.
b) The same.
c) $\sqrt{3}$ times as large.
d) 9 times as large.

9. Of the following, the one which is *not* a vector quantity is

a) Displacement
b) Speed
c) Force
d) Acceleration

10. Planet X has $\frac{1}{2}$ the radius of the earth and $\frac{1}{3}$ of its mass. The value of g on the surface of Planet X is

a) $\frac{3}{2}$ of the value of g on the Earth.
b) $\frac{3}{4}$ of the value of g on the Earth.
c) $\frac{2}{3}$ of the value of g on the Earth.
d) $\frac{4}{3}$ of the value of g on the Earth.

Problems

1. Convert the number

$$6.67 \times 10^{-11} \frac{\mathrm{m}^3}{\mathrm{kg} \cdot \mathrm{s}^3}$$

to units of $\frac{\mathrm{cm}^3}{\mathrm{g} \cdot \mathrm{s}^3}$. (5)

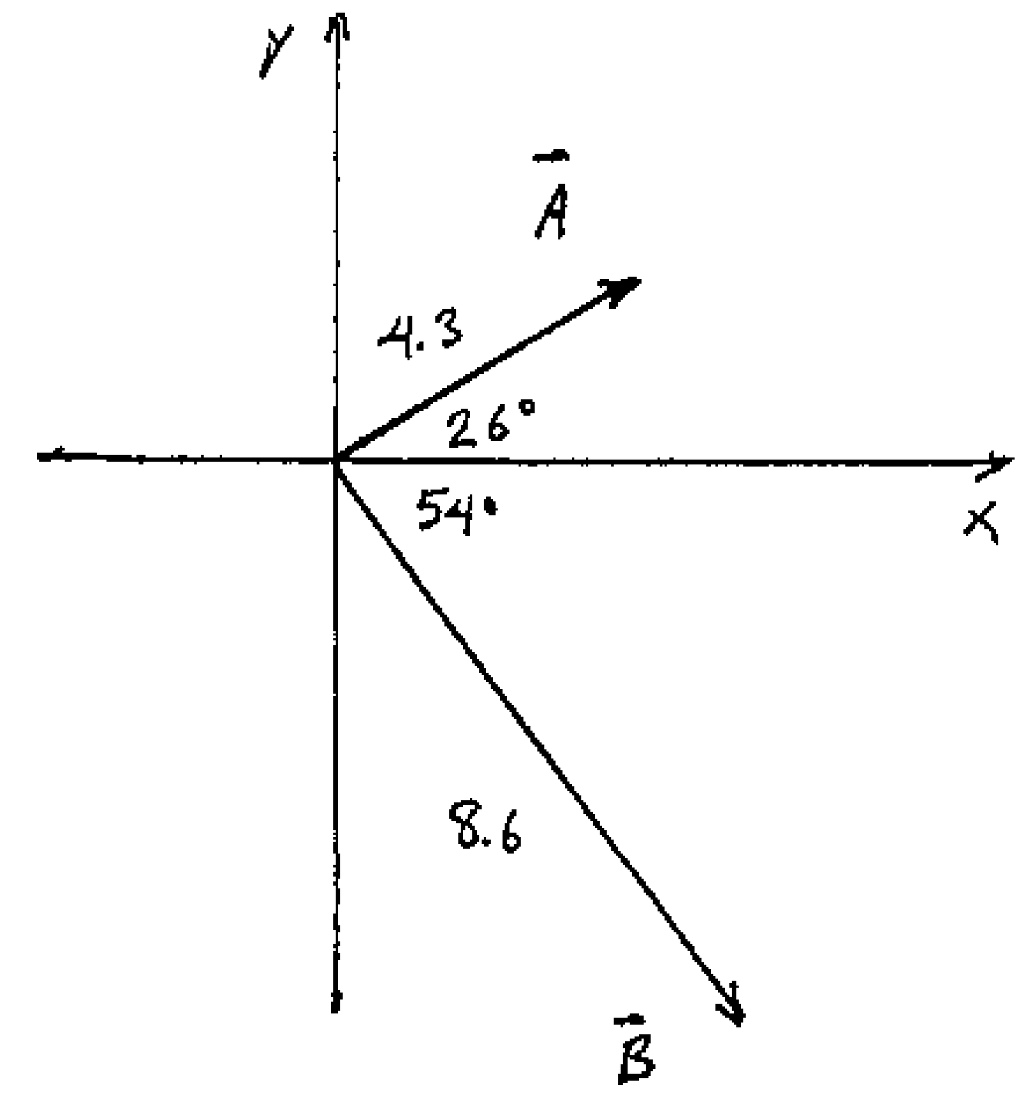
Oops! I meant s^2 in denominator, but it doesn't matter!

$$= \left(6.67 \times 10^{-11} \frac{m^3}{kg \cdot s^3}\right)\left(\frac{100\ cm}{m}\right)^3 \left(\frac{1\ kg}{1000\ g}\right)$$

$$= 6.67 \times 10^{-11} \cdot \frac{(100)^3}{1000} \frac{cm^3}{g \cdot s^3}$$

$$= \boxed{6.67 \times 10^{-8} \frac{cm^3}{g \cdot s^3}}$$

2. Vector **A** has magnitude 4.3 and is directed at 26.0° above the $+x$ axis. Vector **B** has magnitude 8.6 and is directed at 54.0° below the $+x$ axis; see diagram!



a) Find the (rectangular) components of vectors **A** and **B** (3)

$$A_x = 4.3 \cos 26° = \boxed{3.86}$$
$$A_y = 4.3 \sin 26° = \boxed{1.88}$$
$$B_x = 8.6 \cos(-54°) = \boxed{5.05}$$
$$B_y = 8.6 \sin(-54°) = \boxed{-6.96}$$

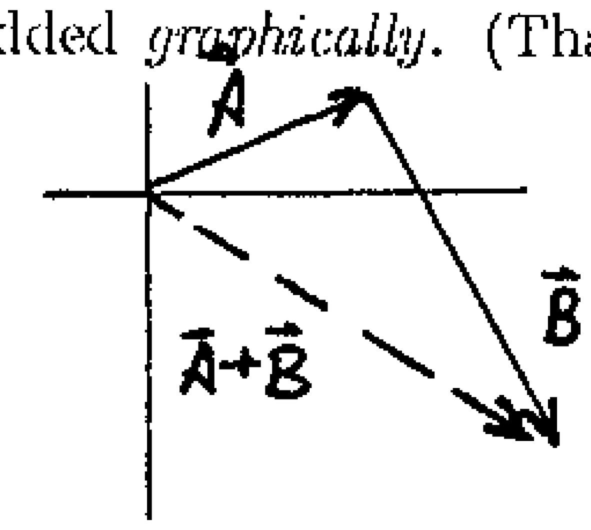
b) Find the direction and magnitude of **A** + **B**. (4)

If $\vec{C} = \vec{A} + \vec{B}$ then

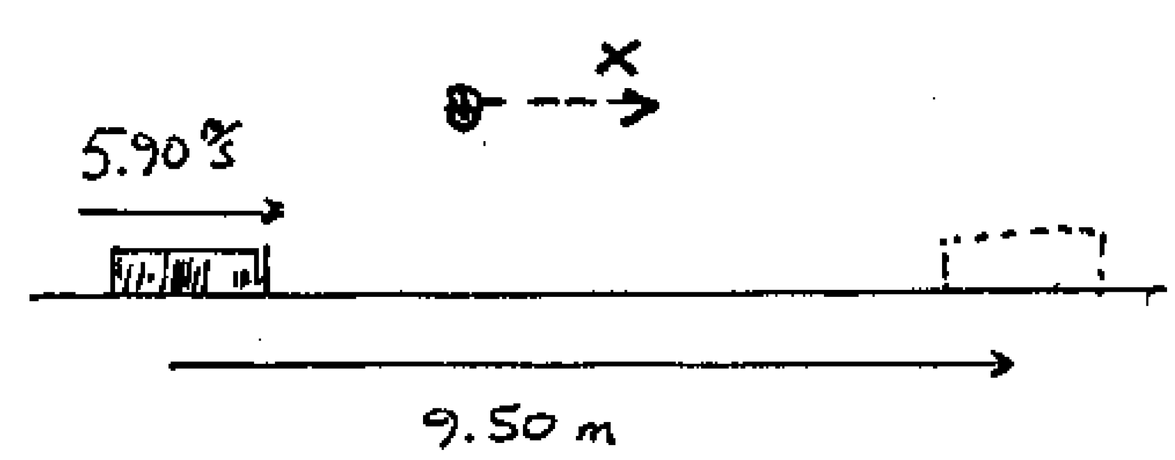
$$C_x = A_x + B_x = 8.92$$
$$C_y = A_y + B_y = -5.07$$

$$C = \sqrt{C_x^2 + C_y^2} = \boxed{10.3} \qquad \theta = \tan^{-1}\left(\frac{C_y}{C_x}\right) = \boxed{-29.6°}$$

c) Make a sketch showing how **A** and **B** are added *graphically*. (That is, show how we "add the arrows" for **A** and **B**.) (3)



3. A shuffleboard disk is given an initial speed of 5.90 $\frac{m}{s}$; it slides over a horizontal (rough) surface and comes to rest after sliding 9.50 m. (Assume that the acceleration of the disk is constant.)



a) Find the acceleration of the disk. Be sure you are clear about its magnitude *and direction*. (4)

$V_0 = 5.90\ \frac{m}{s}$, $V = 0\ \frac{m}{s}$ (comes to rest), $x = 9.50$ m

Use $v^2 = v_0^2 + 2ax$, so

$$a = \frac{v^2 - v_0^2}{2x} = \frac{0^2 - (5.90\ \frac{m}{s})^2}{2(9.50\ m)} = \boxed{-1.83\ \frac{m}{s^2}}$$

I.e. direction of a is "to the left".

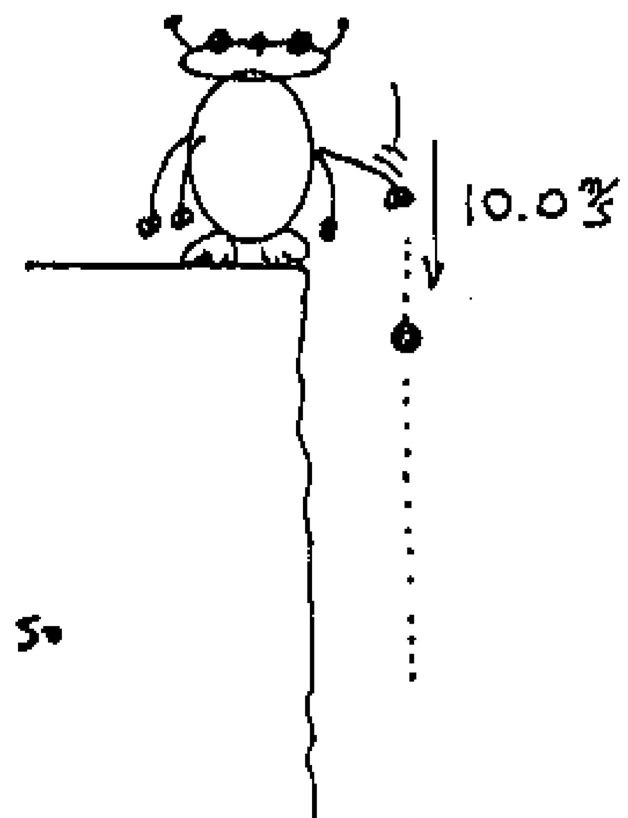
b) Find the time it takes the disk to come to rest. (4)

Use

$v = v_0 + at$, so

$$t = \frac{v - v_0}{a} = \frac{0 - 5.90\ \frac{m}{s}}{(-1.83\ \frac{m}{s^2})} = \boxed{3.22\ s}$$

4. An alien stands at the edge of a cliff on his/her/its home planet and throws a rock straight down with speed $10.0\ \frac{\text{m}}{\text{s}}$. He/she/it finds that the rock falls 34.6 m in 2.0 seconds.



a) What is the value of g on this planet? (It is *not* $9.8\ \frac{\text{m}}{\text{s}^2}$!!) (6)

With $a = -g$ (whatever g is!) we have

$y = v_0 t + \frac{1}{2}at^2$. At $t = 2.0\,\text{s}$, $y = -34.6\,\text{m}$, so

$$-34.6\,\text{m} = (-10.0\,\tfrac{\text{m}}{\text{s}})(2.0\,\text{s}) - \tfrac{1}{2}g(2.0\,\text{s})^2$$

$$\rightarrow \quad -\tfrac{1}{2}g(2.0\,\text{s})^2 = (-34.6 + 20.0)\,\text{m} = -14.6\,\text{m}$$

So $g = \dfrac{2(14.6\,\text{m})}{4.0\,\text{s}^2} = \boxed{7.30\ \tfrac{\text{m}}{\text{s}^2}}$

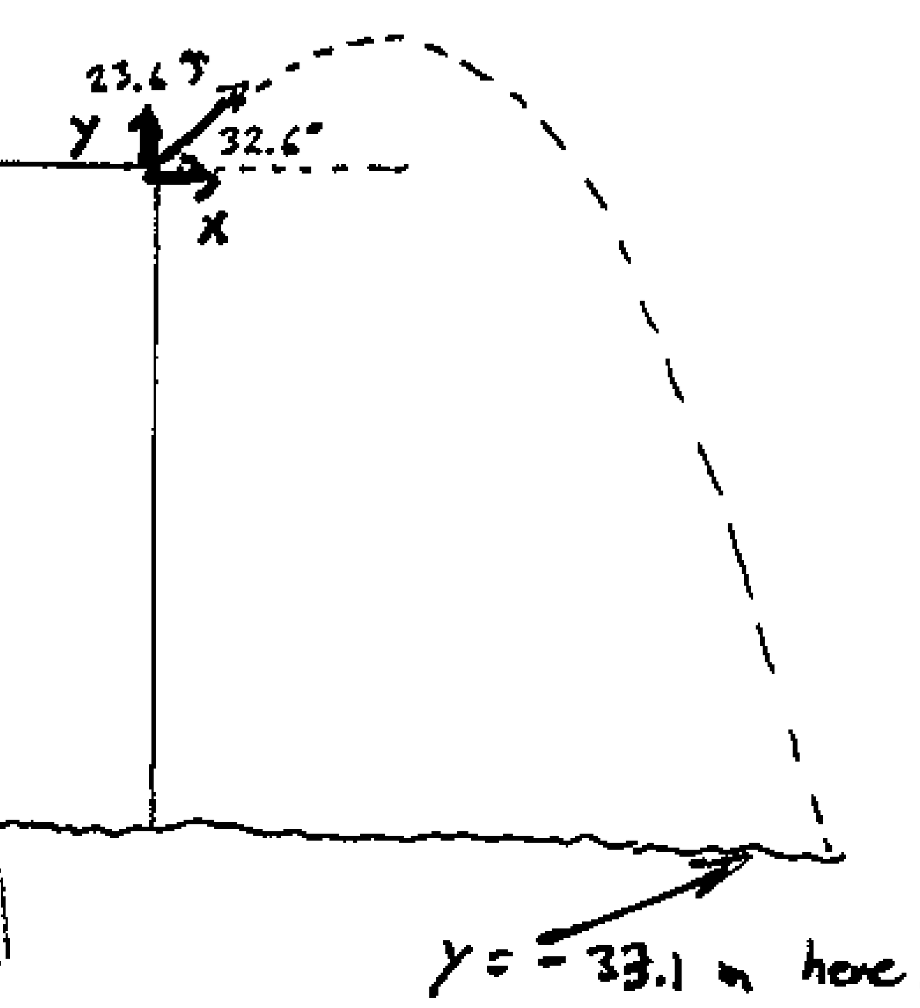
b) What was the speed of the rock after it had fallen for 2.0 s? (3)

At $t = 2.0\,\text{s}$,

$$v = v_0 + at = (-10.0\,\tfrac{\text{m}}{\text{s}}) + (-7.30\,\tfrac{\text{m}}{\text{s}^2})(2.0\,\text{s}) = -24.6\,\tfrac{\text{m}}{\text{s}}$$

So speed is $|v| = \boxed{24.6\ \tfrac{\text{m}}{\text{s}}}$

5. A rock is project off the top of a building (at its edge) at a speed of $23.6\ \frac{\text{m}}{\text{s}}$, at an angle of 32.6° above the horizontal. It strikes the ground below 4.2 s later.



a) How high is the building? (4)

Here, $v_{0y} = (23.6\,\tfrac{\text{m}}{\text{s}})(\sin 32.6°) = 12.7\,\tfrac{\text{m}}{\text{s}}$

so at $t = 4.2\,\text{s}$,

$$y = v_{0y}t + \tfrac{1}{2}at^2 = (12.7\,\tfrac{\text{m}}{\text{s}})(4.2\,\text{s}) + \tfrac{1}{2}(-9.8\,\tfrac{\text{m}}{\text{s}^2})(4.2\,\text{s})^2$$

$= -33.1\,\text{m}$ So bldg. is $\boxed{33.1\,\text{m} \text{ high}}$

b) How far from the base of the building does it land? (4)

What is x at $t = 4.2\,\text{s}$? $v_{0x} = (23.6\,\tfrac{\text{m}}{\text{s}})(\cos 32.6°) = 19.9\,\tfrac{\text{m}}{\text{s}}$

$$x = v_{0x}t + \tfrac{1}{2}a_x t^2 = (19.9\,\tfrac{\text{m}}{\text{s}})(4.2\,\text{s}) + 0 = \boxed{83.5\,\text{m}}$$

c) What are the x and y components of its velocity when it hits the ground? (4)

At $t = 4.2\,\text{s}$,

$$v_x = v_{0x} + a_x t = v_{0x} = \boxed{19.9\ \tfrac{\text{m}}{\text{s}}}$$

$$v_y = v_{0y} + a_y t = (12.7\,\tfrac{\text{m}}{\text{s}}) + (-9.80\,\tfrac{\text{m}}{\text{s}^2})(4.2\,\text{s}) = \boxed{-28.4\ \tfrac{\text{m}}{\text{s}}}$$

d) What is its *speed* and *direction of motion* when it hits the ground? (3)

$$\text{Speed} = v = \sqrt{v_x^2 + v_y^2} = \boxed{34.7\ \tfrac{\text{m}}{\text{s}}}$$

$$\text{Dir} = \tan^{-1}\left(\frac{v_y}{v_x}\right) = \tan^{-1}\left(\frac{-28.4}{19.9}\right) = \boxed{-55.0°}$$

(55° below horiz. direction).

e) At what time did the rock attain maximum height? (4)

When did $V_y = 0$?

$$V_y = 0 = V_{oy} + a_y t = (12.7\tfrac{m}{s}) + (-9.80\tfrac{m}{s^2})\,t$$

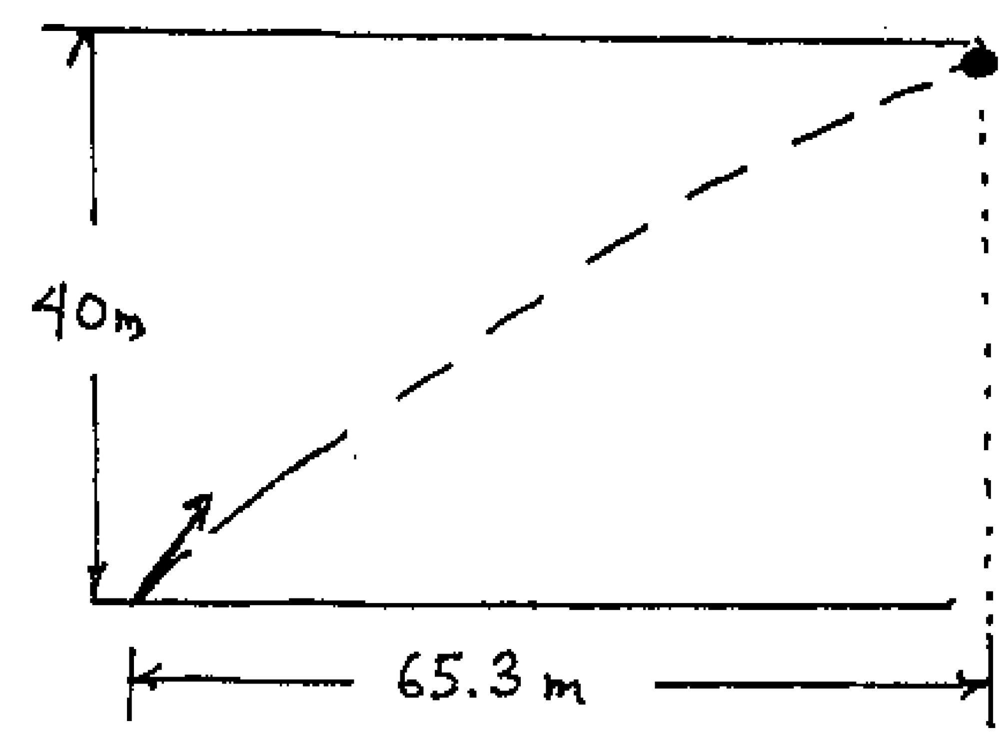
Solve for t:

$$t = \frac{-12.7\frac{m}{s}}{-9.80\frac{m}{s^2}} = \boxed{1.30\,s}$$

f) When the rock attained its maximum height, how far above the launch point was it? (3)

What was y at $t = 1.30\,s$?

$$y = V_{oy}t + \tfrac{1}{2}a_y t^2$$
$$= (12.7\tfrac{m}{s})(1.30s) + \tfrac{1}{2}(-9.8\tfrac{m}{s^2})(1.30s)^2$$
$$= \boxed{8.2\ m}$$



6. A ball is kicked from floor level inside a room with a 40.0 m–high ceiling. 1.74 s later it strikes the ceiling at a point which has a horizontal distance of 65.3 m from the launch point.

a) What was the y–component of the ball's initial velocity? (4)

We know that at $t = 1.74\,s$ $y = 40\,m$

$$y = V_{oy}t + \tfrac{1}{2}a_y t^2$$
$$40\,m = V_{oy}(1.74s) + \tfrac{1}{2}(-9.8\tfrac{m}{s^2})(1.74s)^2$$

Find V_{oy}:

$$(1.74s)\,V_{oy} = 54.8\,m$$
$$V_{oy} = (54.8\,m)/(1.74s) = \boxed{31.5\tfrac{m}{s}}$$

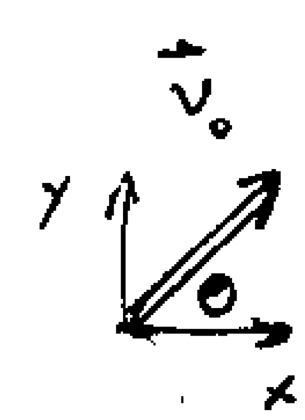
b) What was the x–component of the ball's initial velocity? (4)

We know that at $t = 1.74\,s$, $x = 65.3\,m$

$$x = V_{ox}t + \tfrac{1}{2}a_x t^2 = V_{ox}t$$
$$65.3\,m = V_{ox}(1.74s)$$
$$V_{ox} = \boxed{37.5\tfrac{m}{s}}$$

c) What was the initial speed of the ball? (2)

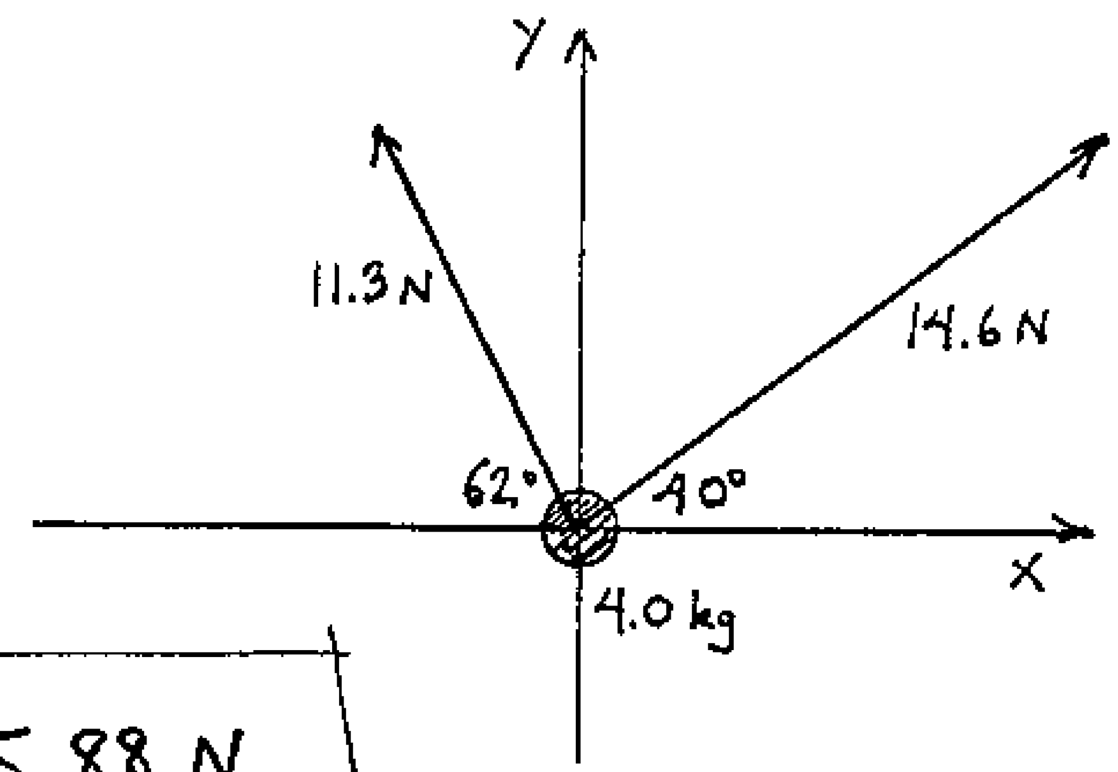
$$V_o = \sqrt{V_{ox}^2 + V_{oy}^2} = \boxed{49.0\tfrac{m}{s}}$$



d) At what angle was the ball kicked? (2)

$$\theta = \tan^{-1}\left(\frac{V_{oy}}{V_{ox}}\right) = \boxed{40.0^\circ}$$

7. Two constant forces (and *only these two!*) act on a 4.0 kg mass which moves in the $x-y$ plane. One force has a magnitude of 14.6 N and points at 40.0° above the x axis; the other force has magnitude 11.3 N and points at 62° above the $-x$ axis. (See picture.)



a) Find the x and y components of the net force acting on the mass. (4)

$$F_{net,x} = -(11.3\,N)\cos 62° + (14.6\,N)\cos 40° = \boxed{+5.88\,N}$$

$$F_{net,y} = +(11.3\,N)\sin 62° + (14.6\,N)\sin 40° = \boxed{+19.4\,N}$$

b) Find the x and y components of the acceleration of the mass. (4)

$$a_x = \frac{F_{net,x}}{m} = \frac{5.88\,N}{4.0\,kg} = \boxed{1.47\,\tfrac{m}{s^2}}$$

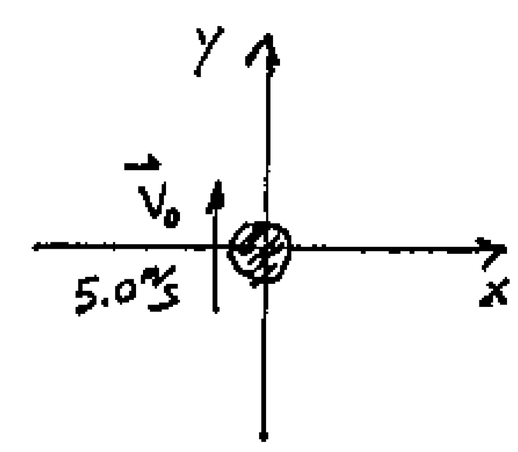
$$a_y = \frac{F_{net,y}}{m} = \frac{19.4\,N}{4.0\,kg} = \boxed{4.84\,\tfrac{m}{s^2}}$$

c) If at $t = 0.0\,\text{s}$ the mass has a velocity of magnitude $5.0\,\frac{\text{m}}{\text{s}}$ in the $+y$ direction, find the components of the mass's velocity at $t = 3.0\,\text{s}$. (3)

At $t = 3.0\,s$,

$$V_x = V_{ox} + a_x t = 0 + (1.47\,\tfrac{m}{s^2})(3.0\,s) = \boxed{4.41\,\tfrac{m}{s}}$$

$$V_y = V_{oy} + a_y t = 5.0\,\tfrac{m}{s} + (4.84\,\tfrac{m}{s^2})(3.0\,s) = \boxed{19.5\,\tfrac{m}{s}}$$



d) Find the speed and direction of motion of the mass at $t = 3.0\,\text{s}$. (3)

$$v = \sqrt{v_x^2 + v_y^2} = \boxed{20.0\,\tfrac{m}{s}}$$

$$Dir = \theta = \tan^{-1}\left(\frac{V_y}{V_x}\right) = \boxed{77.2°}$$