SEAT NUMBER: ____________

Sept. 28, 1999

Name______________________________

Instructor (circle only one): Semmes MURDOCK

Physics 121, Exam #1

1. ____________________ (22)

2. ____________________ (18)

3. ____________________ (12)

4. ____________________ (18)

5. ____________________ (10)

Mult Choice ____________________ (20)

Total ____________________ (100)

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

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

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

$\sum \mathbf{F} = \mathbf{F}_{net} = ma \qquad \sum F_x = ma_x \qquad \sum F_y = ma_y \qquad F = G\frac{m_1 m_2}{r^2}$

$g = 9.80\,\frac{\text{m}}{\text{s}^2} \qquad G = 6.67\times10^{-11}\,\frac{\text{N}\cdot\text{m}^2}{\text{kg}^2} = 6.67\times10^{-11}\,\frac{\text{m}^3}{\text{kg}\cdot\text{s}^2} \qquad \text{Weight} = mg$

For all projectile problems, neglect air resistance.

Multiple Choice (2 pts each)

1. Suppose we see the formula $b = \sqrt{gl}$, where g is the acceleration of gravity and l is a length. What are the MKS units of b ?

(A) $\frac{\text{m}}{\text{s}}$

(B) $\frac{\text{m}^2}{\text{s}}$

(C) $\frac{\text{kg}\cdot\text{m}}{\text{s}^2}$

(D) $\frac{\text{kg}\cdot\text{m}^2}{\text{s}^2}$

2. The surface area of a lake is $26.7\ \text{km}^2$. What is the area of the lake in m^2 ?

(A) $2.67\times10^4\ \text{m}^2$

(B) $2.67\times10^5\ \text{m}^2$

(C) $2.67\times10^7\ \text{m}^2$

(D) $2.67\times10^9\ \text{m}^2$

3. A car drives Northward; over a certain 5.00-second interval, its speed changes from $15.0\frac{m}{s}$ to $5.00\frac{m}{s}$. The magnitude and direction of its acceleration are:

(A) $3.00\frac{m}{s^2}$, Northward

(B) $2.00\frac{m}{s^2}$, Northward

(C) $3.00\frac{m}{s^2}$, Southward

(D) $2.00\frac{m}{s^2}$, Southward

4. Vectors **A** and **B** have magnitudes 4.0 and 3.0 respectively; their directions are not specified. What is the *minimum* possible magnitude of $\mathbf{A}+\mathbf{B}$?

(A) 7.0
(B) 5.0
(C) 1.0
(D) 0.0

5. We drop a rock down a long mineshaft. After 2.00 seconds, what is the magnitude of the rock's acceleration?

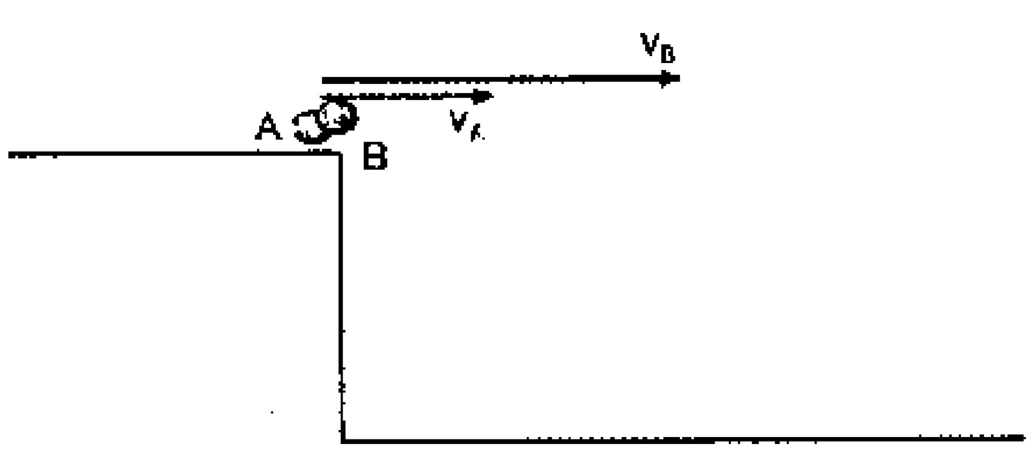
(A) $4.90\frac{m}{s^2}$

(B) $9.80\frac{m}{s^2}$

(C) $19.6\frac{m}{s^2}$

(D) $39.2\frac{m}{s^2}$

6. Ball A and Ball B are both thrown *horizontally* off the edge of a cliff; Ball B is thrown with twice the speed of Ball A. Ball B will land



(A) Twice as far from the base of the cliff as Ball A
(B) Four times as far from the base of the cliff as Ball A
(C) The *same* distance from the base of the cliff as Ball A
(D) There is not enough information to tell.

7. The unit 1 N is equal to

(A) $1\frac{kg\cdot m}{s^2}$

(B) $1\frac{kg\cdot m^2}{s}$

(C) $1\ kg\cdot m^2$

(D) $1\frac{kg\cdot m}{s}$

8. Newton's Third Law states: When two bodies exert forces on one another,
(A) Their velocities are equal in magnitude and opposite in direction.
(B) Their accelerations are equal in magnitude and opposite in direction.
(C) The net force on each mass is zero.
(D) None of the above.

9. A 20.0 N force and a 10.0 N force act in *opposite* directions on a 0.20 kg hockey puck. The puck accelerates at a rate of

(A) $2.0\frac{m}{s^2}$

(B) $12\frac{m}{s^2}$

(C) $50\frac{m}{s^2}$

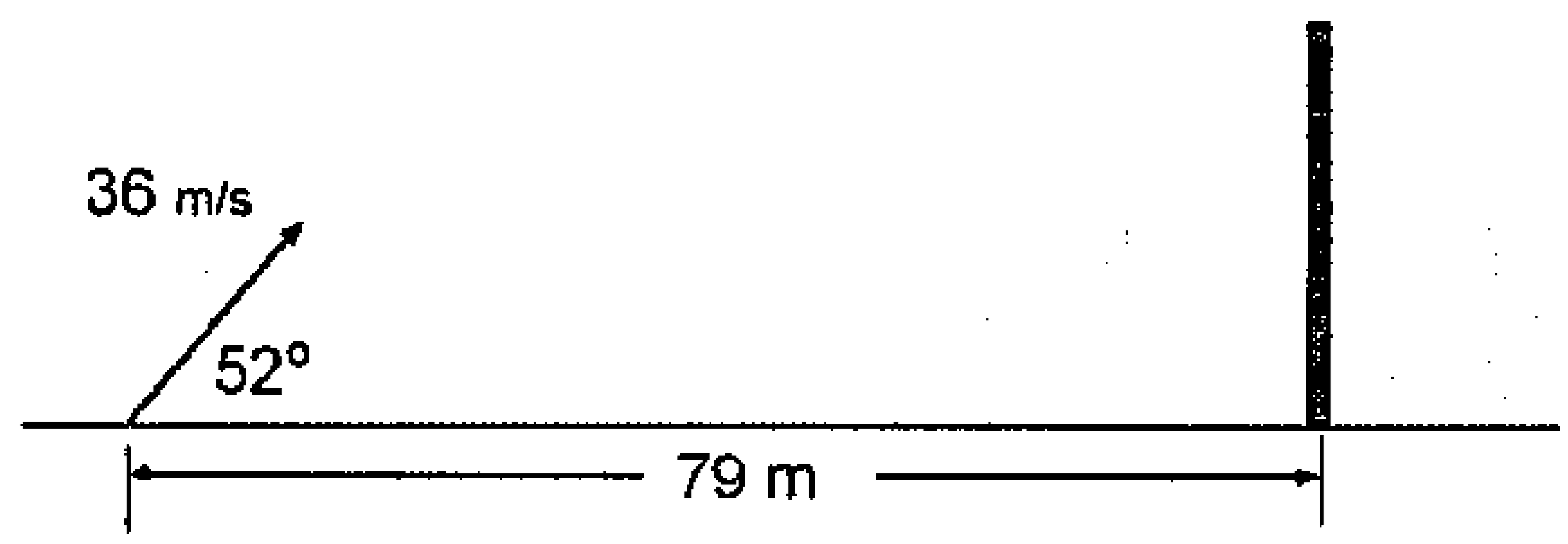
(D) $150\frac{m}{s^2}$

10. Two masses exert a gravitational force F on one another. If we double the distance between the masses and also double the value of *one* of the masses, the force between them is now

(A) $F/2$
(B) F
(C) $2F$
(D) $4F$

Problems. **(Show your work)**

1. A ball is kicked from ground level toward a big wall located 79.0 m away from the point where the ball was kicked. The ball is kicked at an angle of 52.0° above the horizontal with a speed of 36.0 $\frac{m}{s}$.



a) What are the *x* and *y* components of the initial velocity of the ball? (2)

$v_{0x} = v_0 \cos\theta = (36.0 \frac{m}{s}) \cos 52° = 22.2 \frac{m}{s}$

$v_{0y} = v_0 \sin\theta = (36.0 \frac{m}{s}) \sin 52° = 28.4 \frac{m}{s}$

b) How long (time) does it take for the ball to hit the wall? (6)

When does $x = 79.0$ m?

$x = v_{0x} t + \frac{1}{2} a_x t^2 = (22.2 \frac{m}{s}) t$

$79.0 \text{ m} = (22.2 \frac{m}{s}) t$

$\rightarrow \quad t = 3.56 \text{ s}$

c) What is the height of the ball when it strikes the wall? (6)

What is y at this time?

$y = v_{0y} t + \frac{1}{2} a_y t^2$

$= (28.4 \frac{m}{s})(3.6 s) + \frac{1}{2} (-9.8 \frac{m}{s^2})(3.6 s)^2$

$= 39.0$ m

d) What is the speed of the ball when it strikes the wall? (8)

At $t = 3.56$ s,

$v_x = v_{0x} = 22.2 \frac{m}{s}$

$v_y = v_{0y} + a_y t$

$= (28.4 \frac{m}{s}) + (-9.8 \frac{m}{s^2})(3.56 s)$

$= -6.49 \frac{m}{s}$

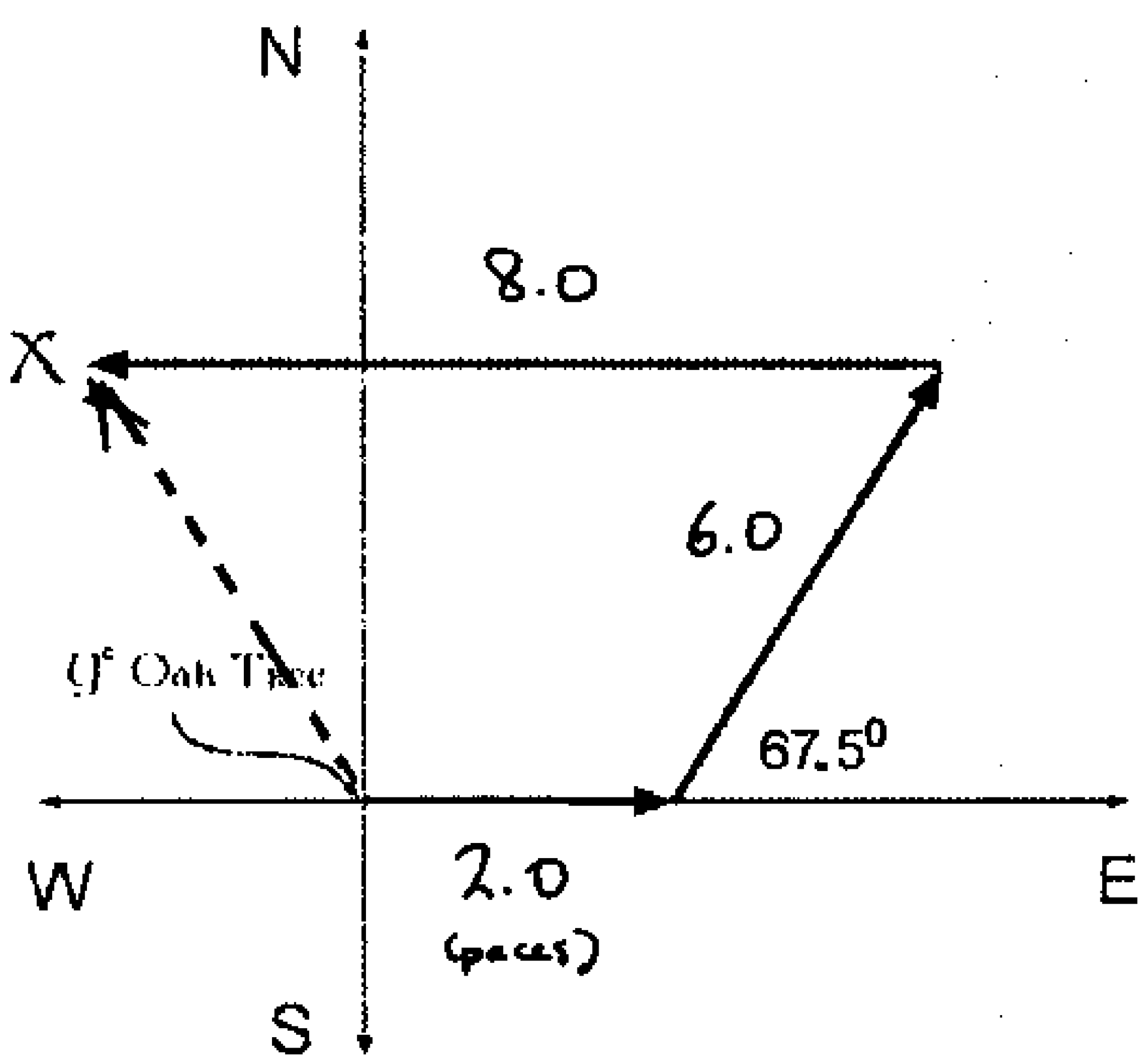
Speed is $v = \sqrt{v_x^2 + v_y^2}$

$= \sqrt{(22.2 \frac{m}{s})^2 + (-6.49 \frac{m}{s})^2}$

$= 23.1 \frac{m}{s}$

2. Bad Bob was thrown off the Polite Pirates' ship because of his revolting table manners[1]. He has been put ashore on a desert isle; he has a map showing where Blackbeard's treasure was buried on the isle, and now Bob is hunting for the treasure.

Starting from the oak tree, Bob takes 2.0 paces due East followed by 6.0 paces North-NorthEast (67.5° North of East) followed by 8.0 paces due West. Each pirate step is 1.05 m and it takes Bob 2.50 minutes to find the spot once he starts from the tree. (In the sketch at the right, the origin is placed at the oak tree, and of course, X marks the spot.)



a) Calculate Bob's net displacement and specify this vector in terms of the East and North components (in units of paces). Sketch this displacement vector on the figure. (7)

$R_x = +2.0_p + (6.0_p)\cos(67.5°) - 8.0_p = -3.7_p$ (East)

$R_y = (6.0_p)\sin(67.5°) = +5.5_p$ (North)

b) Calculate Bob's average *velocity* and give its magnitude (in units of m/s) and direction. Specify the direction in terms of an angle measured from the East axis. (7)

$$\bar{V}_x = \frac{\Delta x}{\Delta t} = \frac{-3.7_p}{(2.50\ \text{min})}\left(\frac{1.05\ \text{m}}{1_p}\right)\left(\frac{1\ \text{min}}{60\ \text{sec}}\right) = -2.6\times10^{-2}\ \text{m/s}$$

$$\bar{V}_y = \frac{\Delta y}{\Delta t} = \frac{+5.5_p}{(2.50\ \text{min})}\left(\frac{1.05\ \text{m}}{1_p}\right)\left(\frac{1\ \text{min}}{60\ \text{sec}}\right) = +3.9\times10^{-2}\ \text{m/s}$$

Mag $= \sqrt{\bar{V}_x^2 + \bar{V}_y^2} = 4.7\times10^{-2}\ \text{m/s}$ Dir $= \tan^{-1}\left(\frac{V_y}{V_x}\right) = 124°$

c) If Bob had walked at a constant speed of $1.5\frac{\text{m}}{\text{s}}$ straight from the oak tree to the final spot (marked X), how long would it have taken him to get there? (4)

The distance along str. line from Tree to X is

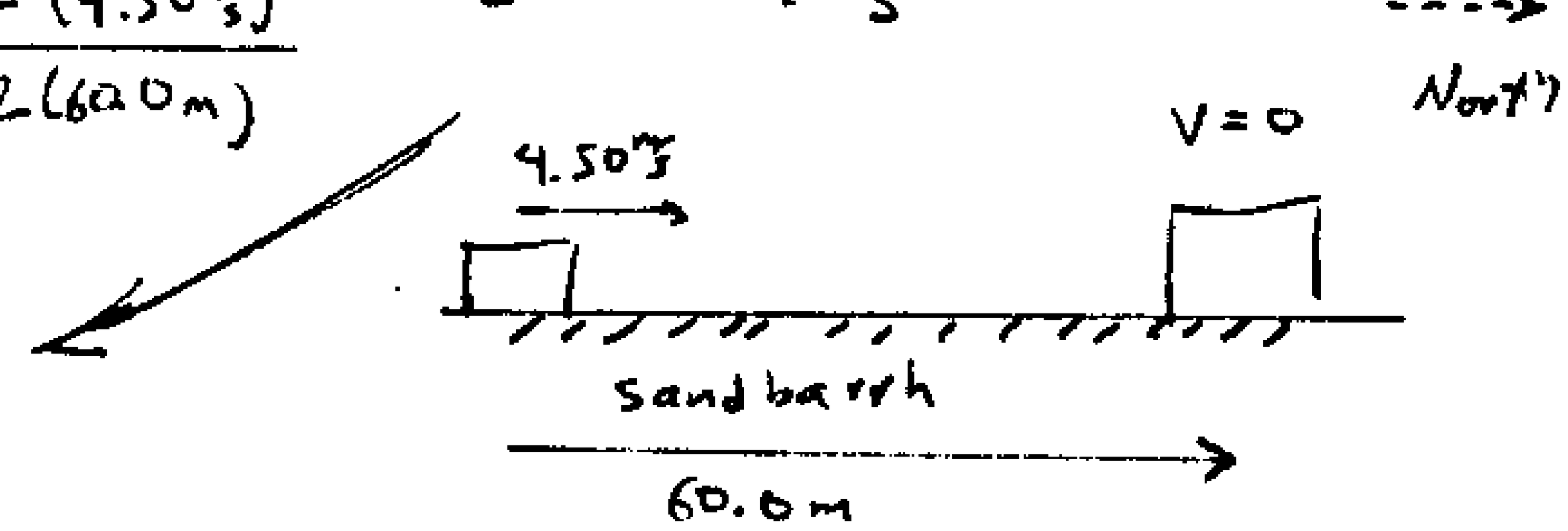
$|R| = \sqrt{(-3.7_p)^2 + (5.5_p)^2} = 6.6_p\left(\frac{1.05\ \text{m}}{1_p}\right) = 7.0\ \text{m}$

Using $s = \frac{d}{t}$ $t = \frac{d}{s} = \frac{7.0\ \text{m}}{1.5\ \text{m/s}} = 4.6\ \text{s}$

3. After putting Bad Bob ashore, the Polite Pirates' ship is heading due North with a speed of $4.50\ \frac{\text{m}}{\text{s}}$ when they run aground on a hidden sandbar[2]. The ship, which has a total mass of 3.50×10^4 kg, travels 60.0 meters along the sandbar before coming to rest. Assume the acceleration of the ship was constant as it slowed and stopped.

a) Determine the acceleration of the pirate ship as it slowed and stopped. State the magnitude and direction of the acceleration. (5)

Use $v^2 = v_o^2 + 2ax$ $a_x = \frac{v^2 - v_o^2}{2x} = \frac{0 - (4.50\ \text{m/s})^2}{2(60.0\ \text{m})} = -0.17\ \text{m/s}^2$



[1] "Arrh, that be a *salad* fork, matey".
[2] "A *sand bar*? Shiver my timbers. Arrh."

Mag $= 0.17\ \text{m/s}^2$

Dir = South.

b) How long (time) did it take the ship to stop? (4)

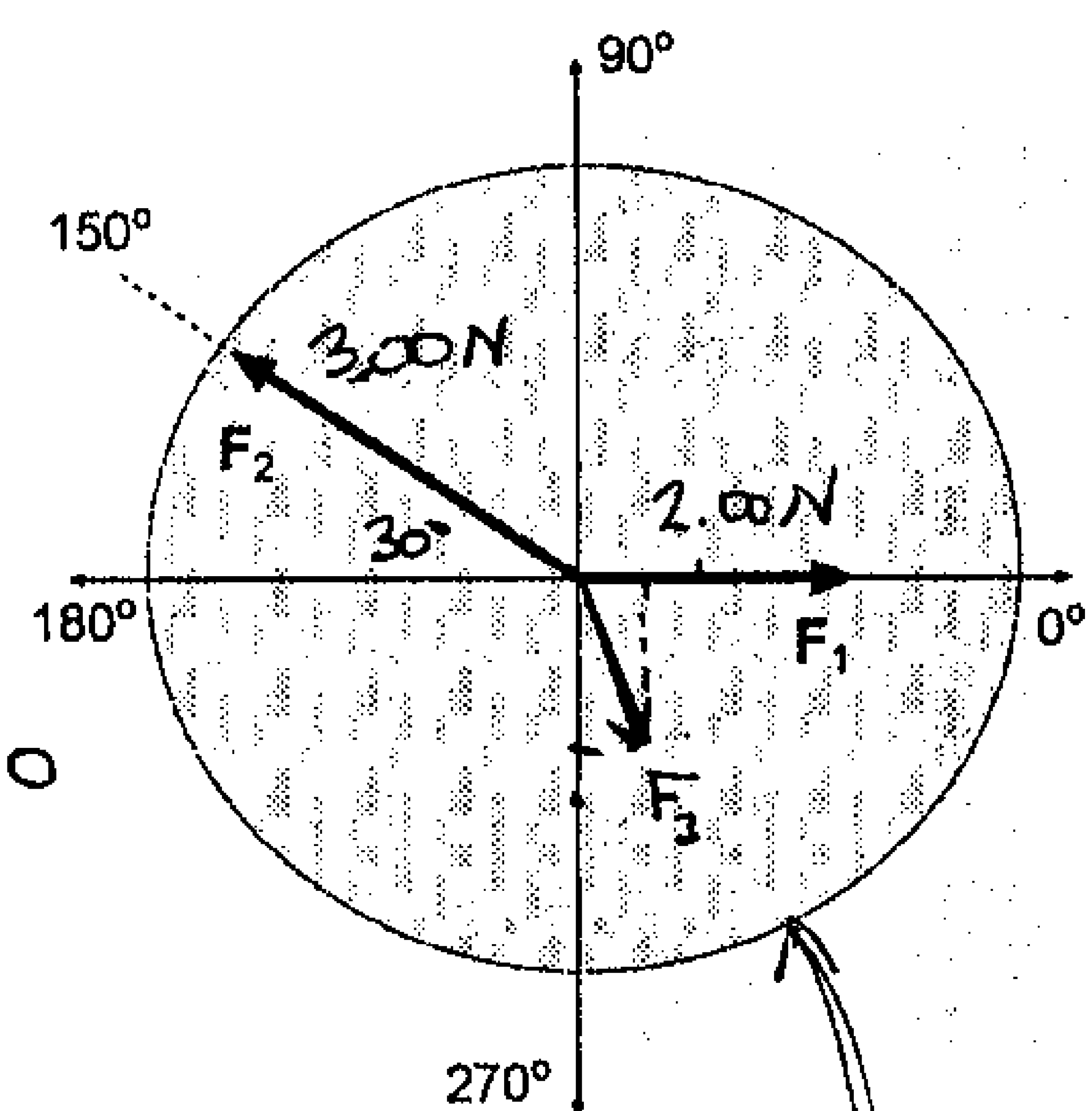
$$a = \frac{v - v_0}{t} \qquad t = \frac{v - v_0}{a} = \frac{0 - (4.50\,\frac{m}{s})}{(-0.17\,\frac{m}{s^2})} = 27\,s$$

c) What was the average external force (magnitude and direction) on the ship as it slowed and stopped? (3)

$$F_x = ma_x = (3.50 \times 10^4\ kg)(-0.17\ \tfrac{m}{s^2})$$
$$= -5.95 \times 10^3\ N$$

Mag = 5950 N   Dir = South

4. Two forces are applied to the center ring of a force table with $|\mathbf{F}_1| = 2.00\,\text{N}$ at 0° and $|\mathbf{F}_2| = 3.00\,\text{N}$ at 150° as shown.



a) Starting from Newton's Laws, determine the magnitude and direction of the third force, $\mathbf{F}_3$, that will balance the first two (so that the ring will not move when the center pin is removed). (15)

The sum must give zero:

$$x: \quad 2.00\,N - (3.00\,N)(\cos 30°) + F_{3x} = 0$$
$$\rightarrow \quad F_{3x} = 0.60\,N$$

$$y: \quad +(3.00\,N)(\sin 30°) + F_{3y} = 0$$
$$\rightarrow \quad F_{3y} = -1.50\,N$$

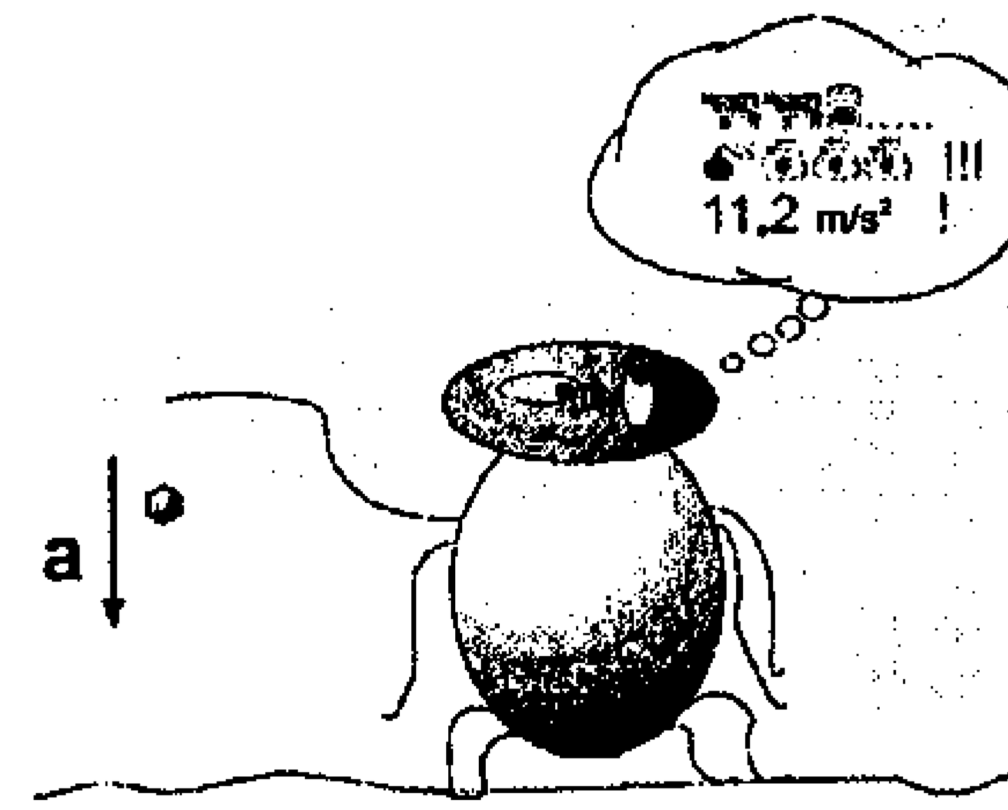
$$|\vec{F}_3| = \sqrt{(F_{3x})^2 + (F_{3y})^2} = 1.6\,N \qquad Dir = \tan^{-1}\left(\frac{F_{3y}}{F_{3x}}\right) = -68°$$

b) Construct the balancing force $\mathbf{F}_3$ graphically on the figure. A rough sketch is sufficient, but it must be clear how you constructed $\mathbf{F}_3$ graphically. (3)

(Used components calc'd in (a)).

5. The planet TrÀ m̃ - L̃ äw has a different mass and radius from that of the Earth; therefore the value of its gravitational acceleration "g" is different.

a) Suppose we drop a 2,5 kg mass on the planet's surface and measure its acceleration to be $11{,}2\,\frac{m}{s^2}$. What is gravitational force of the planet on this mass? (The magnitude will suffice!) (2)



$g' = 11.2\,\frac{m}{s^2}$.

Force of (planet's) gravity on mass is

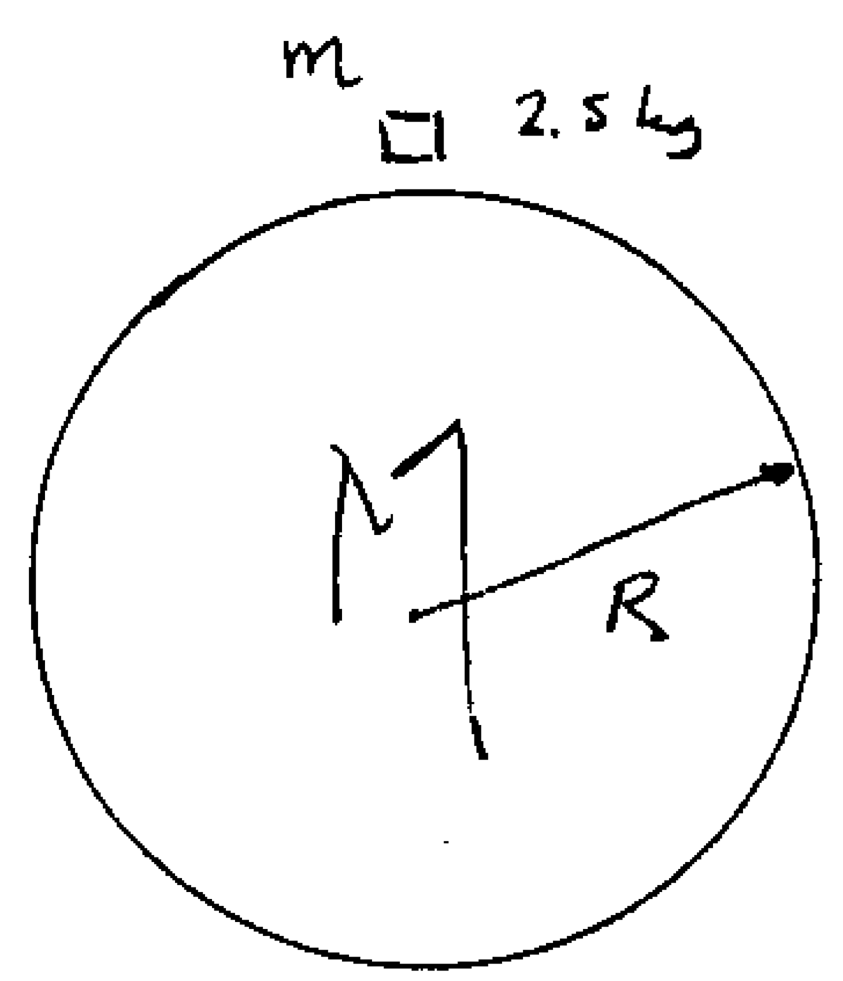
$$F = ma = mg' = (2.5\text{ kg})(11.2\,\tfrac{m}{s^2}) = 28\text{ N}$$

b) The radius of the planet TrÀ m̃ - L̃ äw is 7450 km. What is the mass of the planet TrÀ m̃ - L̃ äw? (8)

The force calculated in (a) is the force of the entire planet on the mass:

$$F = G\frac{Mm}{R^2}$$

Solve for M:



$R = 7.450\times10^{6}\text{ m}$

$$M = \frac{FR^2}{Gm}$$

$$= \frac{(28\text{ N})(7.450\times10^{6}\text{ m})^2}{(6.67\times10^{-11}\,\frac{N\cdot m^2}{kg^2})(2.5\text{ kg})}$$

$$= 9.3\times10^{24}\text{ kg}$$