National University of Computer and Emerging Sciences, Lahore Campus				
	Course:	**Applied Physics**	**Course Code:**	**EE117**
	Program:	**BS (CS), BS (DS), BS (SE)**	**Semester:**	**Fall 2020**
	Duration:	**4 years**	**Total Marks:**	**40**
	Date:	**20-10-2020**	**Weight:**	**15%**
	Section(s):	**All**	**Page(s):**	**6**
	Exam:	**Midterm 1**	**Max. Time**	**90 minutes**
	Name:		**Roll No./Section**	
Instructions/Notes:	**Attempt all questions.** **Write your answer within the space provided only.** **Do not attach any rough sheet with the paper.**			

Question 1: You are standing 100 m north of your car when an alligator appears 20 m north of you and begins to run toward you at 8 m/s. At the same moment you start to run toward your car at 5 m/s. (a) Will you reach the car before the alligator overtakes you? (b) If not, how far from your car does the alligator have lunch? (10 marks)

Solution:

(*a*) You would need

$$t_1 = \frac{s_1}{v_1} = \frac{100\text{ m}}{5\text{ m/s}} = 20\text{ s}$$

to reach your car, but the alligator would need only

$$t_2 = \frac{s_2}{v_2} = \frac{120\text{ m}}{8\text{ m/s}} = 15\text{ s}$$

Hence the alligator will overtake you before you get to the car. Too bad.

(*b*) If the alligator catches up with you in the time t at the distance d from your car, you will have gone $100\text{ m} - d$ at the velocity v_1 and the alligator will have gone $120\text{ m} - d$ at the velocity v_2. Thus there are two formulas for t,

$$t = \frac{100\text{ m} - d}{v_1} = \frac{120\text{ m} - d}{v_2}$$

and so

$$\frac{100\text{ m} - d}{5\text{ m/s}} = \frac{120\text{ m} - d}{8\text{ m/s}}$$

Solving for the distance d gives

$$(8\text{ m/s})(100\text{ m} - d) = (5\text{ m/s})(120\text{ m} - d)$$
$$800\text{ m} - 8d = 600\text{ m} - 5d$$
$$3d = 200\text{ m}$$
$$d = 67\text{ m}$$

Question 2: A map suggests that Atlanta is 730 miles in a direction 5.00° north of east from Dallas. The same map shows that Chicago is 560 miles in a direction 21.0° west of north from Atlanta. Figure shows the location of these three cities. Modeling the Earth as flat, use this information to find the displacement from Dallas to Chicago. (10 marks)

Solution:

Choose the positive x-direction to be eastward and positive y as northward. Then, the components of the resultant displacement from Dallas to Chicago are

$$R_x = \Sigma x = (730\text{ mi})\cos 5.00° - (560\text{ mi})\sin 21.0° = 527\text{ mi}$$

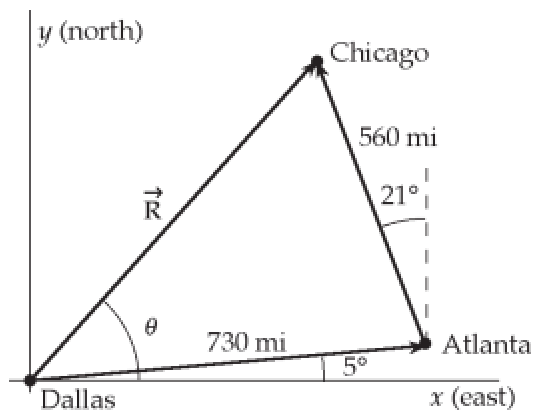
and $$R_y = \Sigma y = (730\text{ mi})\sin 5.00° + (560\text{ mi})\cos 21.0° = 586\text{ mi}$$

$$R = \sqrt{R_x^2 + R_y^2} = \sqrt{(527\text{ mi})^2 + (586\text{ mi})^2} = 788\text{ mi}$$

$$\theta = \tan^{-1}\left(\frac{\Sigma y}{\Sigma x}\right) = \tan^{-1}(1.11) = 48.0°$$

Thus, the displacement from Dallas to Chicago is

$\vec{\mathbf{R}} = \boxed{788\text{ mi at }48.0°\text{ N of E}}$



Question 3 (a): An athlete participates in a long–jump competition, leaping into the air with a velocity v_0 at an angle θ_0 with the horizontal. Derive the expression for the maximum displacement in vertical direction, Δy_{max}, in terms of v_0, θ_0, and g. (3 marks)

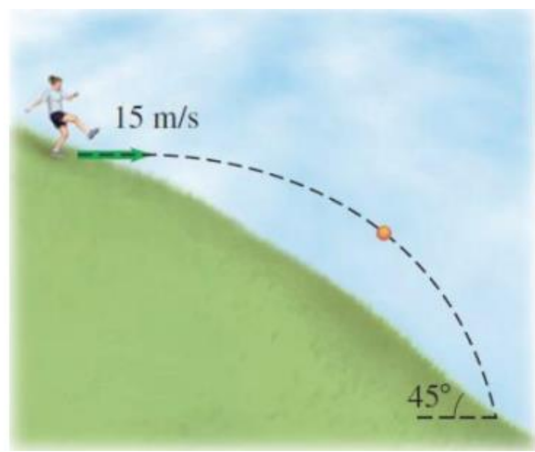
Solution:

$$\Delta y_{\max} = (v_0 \sin\theta_0) t_{\max} - \frac{1}{2} g t_{\max}^2,$$

$$= (v_0 \sin\theta_0) \frac{v_0 \sin\theta_0}{g} - \frac{1}{2} g \left(\frac{v_0 \sin\theta_0}{g} \right)^2,$$

$$\Delta y_{\max} = \frac{v_0^2 \sin^2\theta_0}{g}.$$

Question 3 (b): A rock is kicked horizontally at 15 m/s from a hill with a 45 ◦ slope (see Fig. below). How long does it take for the rock to hit the ground? (7 marks)



Solution:

We are given that,

Speed of rock $= v = 15\ m/s$.

Slope of hill $= \theta = 45^\circ$

Time taken to hit the ground $= t = ?$

Time taken to hit the ground can be calculated by the distance covered in x and y direction.

$\because$ rock is kicked in x-direction.

$$v = v_{0x} = 15\ m/s$$

and $$v_{0y} = 0\ m/s.$$

Distance moved by the rock in x-direction will be,

$$x = v_{0x} t = 15t.$$

vertical distance will be

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

When rock hit the ground $x = y$

$\because \cancel{y}/x = \tan\theta.$

$y/x = \tan 45^\circ$

$y/x = 1$

$y = x$

$$\Rightarrow \quad \frac{1}{2} g t^2 = 15t$$

$$\frac{1}{2} g t = 15$$

$$t = \frac{15 \times 2}{g} = \frac{30}{9.8}$$

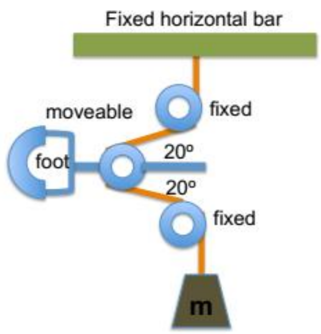
$$\boxed{t = 3.06\,s}$$

Question 4 (a): A space explorer is moving through space far from any planet or star. He notices a large rock, taken as a specimen from an alien planet, floating around the cabin of the ship. Should he push it gently, or should he kick it toward the storage compartment? Explain. (2 marks)

Solution:

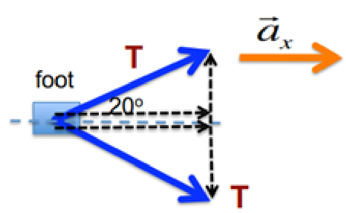
If it has a large mass, it will take a large force to alter its motion even when floating in space. Thus, to avoid injuring himself, he should push it gently toward the storage compartment.

Question 4 (b): A traction device employs 3 pulleys to a patient in the hospital to stretch his recovering leg. The middle pulley is attached to a strap that ties with the patient foot. Suppose the patient puts a mass m to supply tension on the ropes. (a) Draw the free-body diagram. (b) Resolve Newton's 2nd law of motion into x and y components. (c) Find the value of that mass m if the forces exerted on the strap by the middle pulley is 165 N. Assume $g = 9.81\ m/s^2$. (8 marks)



Solution:

The rope supports the hanging mass **m**. The pulleys simple change the direction of tension: $T = mg$



In the y-direction

$$\sum F_y = T\sin(20) - T\sin(20) = 0$$

In the x-direction, positive to right

$$\sum F_x = T\cos(20) + T\cos(20)$$

$$165 = 2T\cos(20)$$

$$T = \frac{165}{2\cos 20} = 87.79N$$

Mass of the weight: $T = mg$

$$m = T/g = 87.79/9.81 = 8.95 \text{ kg}$$