Test Questions - Exam I

1. The moon goes around the Earth in a circular orbit of radius 400,000 km and takes about 27 days. What is the orbital speed of the moon?

2. Compare the orbital speed of the moon with that of a person located on Earth at a latitude of 45°. Radius of Earth is 6400 km.

3. A person starts at the origin, travels 90m along y direction, then 50m along a direction of 30° with respect to the x-axis and finally 15m along the x-axis. What is the displacement vector of this journey? Why?

4. If you go around a circle of radius 2m in 10 secs what is your average (i) speed, (ii) velocity? Why?

5. Two friends, A and B are 300m apart and walk toward one another at +1 m/sec $\hat{x}$ and -2 m/sec $\hat{x}$. A falcon flies from A to B at 5 m/sec and then turns around and flies from B to A at 5 m/sec. The back and forth flight continues till A and B meet.

a) Where do A and B meet and (b) what is the total distance travelled by the bird? Why?

6. The distance between Breezewood and Pittsburgh is 100 miles and the posted speed limit is 60mph. You have been travelling at a steady speed of 65mph. How long a break do you need to ensure that your average speed falls below the limit? Why?

7. We are told that an object has a constant velocity of $\underset{\rightarrow}{v} = 3m/s\,\hat{x} - 5m/s\,\hat{z}$. If the object starts from rest at $x = 2m$, $z = 5m$, what is its position vector at $t = 10$ secs?

8. We are told that an object is at 100 m at $t = 0$, has a velocity of $-50m/s\,\hat{x}$ and an acceleration of $20m/s^2\,\hat{x}$. Write down the equation which relates $\underset{\rightarrow}{x}$ to time.

9. The position of an object is described by the equation $\underset{\rightarrow}{x} = (4 + 10t - 2t^2)\,\hat{x}$. What are the dimensions (not units) of the constants on the right side?

10. You are driving on a level road at $\vec{v} = 20\ m/sec\,\hat{x}$ when you notice that a deer is ahead of you at about 100m. What acceleration will you need to make sure that you don't hit the animal?

11. In order to qualify in a 1500m dash a runner must maintain an average speed of 15m/sec. A runner runs the first half at 10m/sec. What speed will she need in the 2nd half in order to qualify? Why?

12. The planets go in circular orbits around the sun, and the time to go around once (T_p) varies as the $\frac{3}{2}$ power of the orbital radius (R_p), that is,

$$T_p \text{ is proportional to } R_p^{3/2}$$

As one goes further away from the sun (increase R_p) will the planetary speed increase, reduce or stay the same? Why?

13. Given that $\vec{x} = (-5 - 3t + 2t^2)\hat{x}$ where distances are in meters and times in seconds, calculate the position velocity and acceleration at $t = 1$ sec. When will it's velocity be zero and (ii) $x = 0$. Why?

14 Consider a tower of height 30 m, a stone is thrown down from it at a velocity of $\vec{V}_0 = -10 m/s \hat{y}$ and at the same time a stone is launched upward from the bottom with a velocity of $+10 m/s \hat{y}$. Where will the stones cross one another and at what time will this happen? Why?

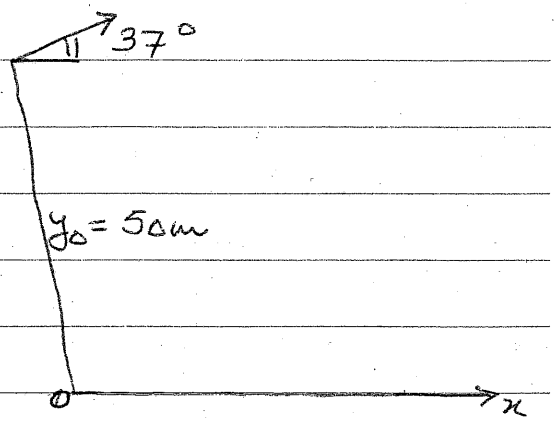
15. A ball is thrown vertically upward $(+\hat{y})$ and reaches a height of 10 meters before returning to ground. (i) what was its initial velocity (ii) why does it stop rising, (iii) what is its acceleration at the highest point? (iv) how long will it be in the air before returning to ground (v) If you wish to double the height to which it should go, by what factor would you change its initial velocity?

16. A player kicks a ball giving it a velocity of 20m/s at an angle of 53° above the horizon (x-axis). a) how long before it reaches the maximum height, b) what is the maximum height? c) what is the velocity vector at the maximum height d) what is the acceleration when it is 10m above the ground e) where will the ball land f) what is the velocity vector just before it lands? g) what is the acceleration just before it lands.

17. In Prob 16 if there was a wall of height 3 m at a point $x = 30m$ would the ball clear the wall. If so, what will its velocity and acceleration be at that point? why?

18. Draw graphs of position, velocity and acceleration as functions of i) x, ii) t for Prob 16.

19. Now the ball is launched from a 50m high tower ~~with~~ at 20m/s ~~to~~ and making an angle of 37° with the horizontal?



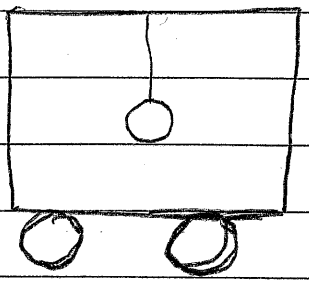
i) write down the x & y components of the velocity at $t=0$. ii) how high will the ball go. (iii) when will it be at $y = 50m$ again (iv) what will be the values of $\underset{\rightarrow}{x}$, $\underset{\rightarrow}{v}$ and $\underset{\rightarrow}{a}$ at that time. (v) how far will the ball be from the origin ($x=0$, $y=0$) at what time

20 Forces are said to come in action-reaction pairs. Near the Earth's surface an object of mass M has a weight of $\underset{\rightarrow}{W} = -Mg_E\hat{y}$. where does the reaction force to the weight vector act? ($g_E = 9.8m/s^2$).

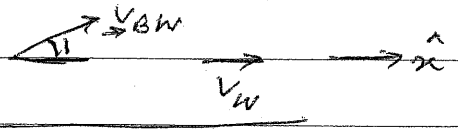
21. State the principle of relativity in your own words.

22. What is an inertial observer?

23 A pendulum is hanging vertically in a car which is at rest. If the car gets an acceleration of $\vec{a} = 5 m/s^2 \hat{x}$ will the pendulum still be vertical? Explain.

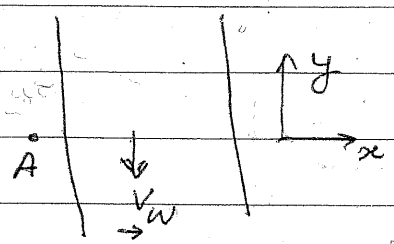


24. You are travelling by a boat in a river where the water flows at $(5 m/hr)\,\hat{x}$. If your velocity with respect to the water is 10 m/hr at an angle of 60° to $\hat{x}$, what is your velocity with respect to the shore



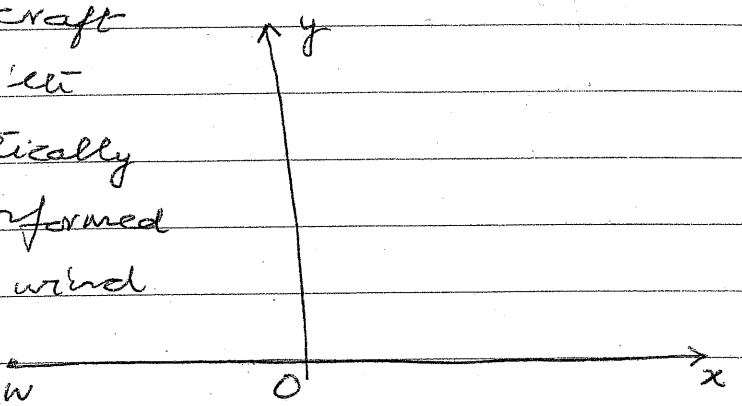
25. As shown, velocity of water in a river is

$\vec{v}_W = -0.3 m/s\,\hat{y}$ [Here $\hat{y}$ is not vertical].



If you were in a boat whose speed with respect to the water is 0.5 m/s (no matter what the direction) what direction would you go so as to land directly opposite to the point A? What would your velocity be with respect to the shore

26 A pilot whose aircraft flies at 100 km/hr with respect to air is vertically above O when he is informed that there is a 50 km/hr wind blowing along $-\hat{y}$. He wants to get to W where OW = 86.6 km. What direction should he choose and how long will it be before he reaches above W.



27. Your mass on Earth is 100 kg. If you go to the moon (a) what is your mass there (b) what is your weight there if $g_{moon} = \frac{1}{6}(g_{earth})$?

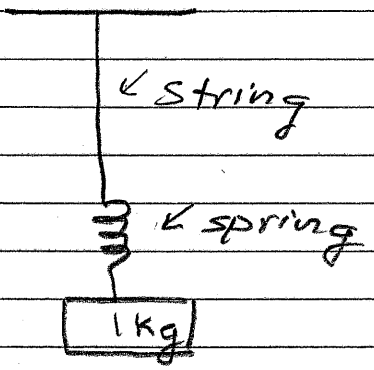
28. A projectile is launched from $x = 0, y = 0$ with a velocity V_0 at angle θ_0 above the horizon, show that for a given V_0 the range will be maximum when $\theta_0 = \frac{\pi}{4}$.

29. You are pushing a refrigerator at a constant velocity of 2 m/s $\hat{x}$. Is the refrigerator in equilibrium.

30. You pull on a string which is tied to a hook on a wall with force $\vec{F}$. Why does the string develop a tension (T) whose magnitude is equal to F? What are the directions of T?

31. Now that you are a "physicist" & a friend asks you: "how do you measure (i) speed, (ii) diameter, of the moon, what would you tell her? (Prob 4-1

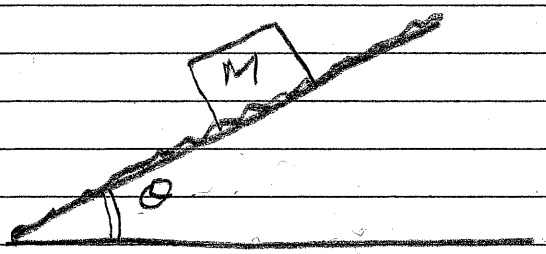
32 As shown, a mass of 1kg is hanging vertically from a string/spring combination. If the mass is in equilibrium



i) What is the tension in the string? Why?

ii) The spring constant is 100 N/m. What is the change in the length of the spring? Why?

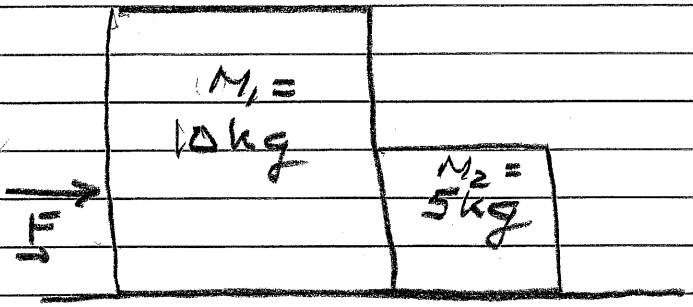
33 As shown, a mass is lying on a rough inclined plane. If



on increasing θ the mass just begins to slide when θ = 30° what is the coefficient of friction between mass and plane.

34 4-6

35 The masses are lying on a smooth horizontal table. If you apply a force of $\underline{F} = 150N\hat{x}$ to the 10kg mass, what is



i) acceleration of M_1?

ii) acceleration of M_2?

iii) Force acting on M_2?

Why?

36 4-9

37 4-10

38 4-11

39 4-14, 15