

Midterm Examination

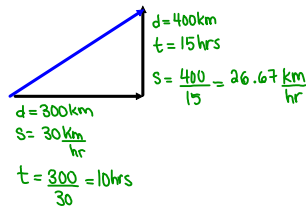
Physics 204/1

March 4, 2009

Time Allowed: 1 1/4 hr.

Maximum marks: 30

1. A car makes a trip of 300 km to east at an average speed of 30 km/hr and then goes 400 km north in 15 hours to reach its destination. (a) What is the average speed for the whole trip? (b) What is the displacement of the destination from the starting point? (c) What is the average velocity for the whole trip? (1,1,1)



total distance / total time a) $\frac{300+400}{10+15} = 28 \frac{\text{km}}{\text{hr}}$

b) $\sqrt{300^2+400^2} = 500\text{km}$

total displacement / total time c) $\frac{500}{25} = 20 \frac{\text{km}}{\text{hr}}$

2. If $\vec{A} = 2\hat{i} - \hat{j} + 4\hat{k}$ and $\vec{B} = -3\hat{i} - 2\hat{j} + 4\hat{k}$, (a) find $\vec{A} - 2\vec{B}$, (b) find $\vec{A} \cdot \vec{B}$ (c) $\vec{A} \times \vec{B}$

a) $2\hat{i} - \hat{j} + 4\hat{k} - 2(-3\hat{i} - 2\hat{j} + 4\hat{k}) = 2\hat{i} - \hat{j} + 4\hat{k} + 6\hat{i} + 4\hat{j} - 8\hat{k} = 8\hat{i} + 3\hat{j} - 4\hat{k}$

b) $\vec{A} \cdot \vec{B} = (2\hat{i} - \hat{j} + 4\hat{k}) \cdot (-3\hat{i} - 2\hat{j} + 4\hat{k}) = (2)(-3) + (-1)(-2) + (4)(4) = -6 + 2 + 16 = 12$

c) $\vec{A} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & -1 & 4 \\ -3 & -2 & 4 \end{vmatrix} = \begin{vmatrix} -1 & 4 \\ -2 & 4 \end{vmatrix} \hat{i} - \begin{vmatrix} 2 & 4 \\ -3 & 4 \end{vmatrix} \hat{j} + \begin{vmatrix} 2 & -1 \\ -3 & -2 \end{vmatrix} \hat{k}$

$\begin{vmatrix} a & b \\ c & d \end{vmatrix} = ad - bc = 4\hat{i} - 20\hat{j} - 7\hat{k}$

3. A jet plane lands with a velocity of 100m/s and can accelerate at a maximum rate of -5.0 m/s^2 as it comes to rest. (a) From the instant it touches the runway, what is the minimum time needed before it stops? (b) Can the plane land at the airport where the runway is 1.2 km long? (1,2)

V_i	100
V_f	0
a	-5
d	
t	

$V_f = V_i + at$

$0 = 100 - 5t$

$t = 20\text{s}$

$V_f^2 = V_i^2 + 2ad$

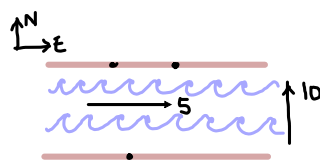
$0 = 100^2 + 2(-5)d$

$-10000 = -10d$

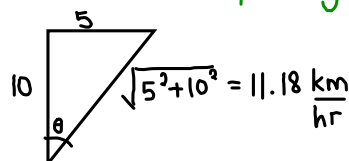
$d = 1000\text{m}$

yes, it only needs 1km.

4. A boat crosses a wide river with a speed of 10 km/hr (relative) to water. The river has a uniform speed of 5 km/hr due east relative to earth. (a) Determine the speed of the boat relative to the stationary ground observer. (b) In what direction should the boat be heading to reach an opposite point across the river? (1,2)



make a velocity triangle.



b) $\tan \theta = \frac{5}{10}$

$\theta = \tan^{-1}\left(\frac{1}{2}\right) = 26.5^\circ$ west of north.

5. A ball is thrown horizontally from the top of a building 50 m high. The ball strikes the ground at a point 100 m from the base of the building. Find (a) the time taken by the ball during the flight, (b) the initial velocity of the ball. (1,2)

	x → +	y ↓ +
v_i	31.3	0
v_f		
a	0	9.8
d	100	50
t		

$$y: d = v_i t + \frac{1}{2} a t^2$$

$$50 = 0 + \frac{1}{2} (9.8) t^2$$

$$t = 3.19 \text{ s}$$

$$x: 100 = v_i (3.19) + \frac{1}{2} (0) (3.19)^2$$

$$v_i = 31.3 \text{ m/s} \uparrow$$

6. A man weighs 980 N on the earth ($g = 9.8 \text{ m/s}^2$). (a) What would be his weight on Jupiter, where the free fall acceleration is 25.9 m/s^2 ? (b) How much would be his mass on Jupiter? (c) What is his mass on the earth? (2,1,1)

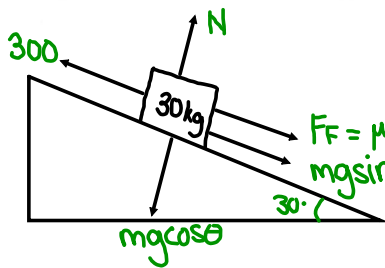
ⓐ $W = mg$ ⓑ Mass on Jupiter = mass on earth = 100 kg

$$980 = m(9.8)$$

$$m = 100 \text{ kg}$$

ⓐ $W = mg = 100(25.9) = 2590 \text{ N}$

7. A 300 N force applied up the plane pushes a 30-kg box up a rough sloping plane, inclined at 30° angle to the horizontal, having a coefficient of kinetic friction of 0.3. (a) What is the frictional force? (b) What is the acceleration of the box? (2,1)



$$y: N = mg \cos \theta = 30(9.8) \cos 30 = 254.6$$

a) $F_f = \mu N = 0.3(254.6) = 76.38 \text{ N}$

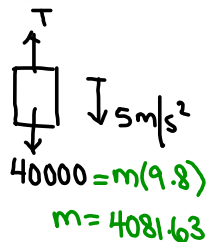
x: b) $F_{\text{net}} = ma$

$$300 - F_f - mg \sin \theta = ma$$

$$300 - 76.38 - 30(9.8) \sin 30 = 30a$$

$$a = 2.554 \text{ m/s}^2$$

8. An elevator weighing 40,000 N comes down with acceleration of 5 m/s^2 . (a) What is the tension in the supporting cable? (b) What would be the tension if the elevator were going up with an acceleration of 8 m/s^2 ? (3)



$$F = ma$$

$$40000 - T = 4081.63(5)$$

$$T = 19591.8 \text{ N}$$

ⓑ $T - 40000 = 4081.63(8)$

$$T = 72653.04 \text{ N}$$

9. A fullback weighing 900 N is running with a speed of 8 m/s due north. Find his momentum $p = mv$

$$900 = 9.8m$$

$$m = 91.83$$

$$p = (91.83)(8) = 734.69 \text{ kg m/s}$$

10. A ball of mass 1 kg is attached to the end of a cord whose length is 90 cm. The ball is whirled in a horizontal circle. If the cord can withstand a maximum tension of 75 N, what is the maximum speed the ball can have before the cord breaks? (3)

$$F = ma$$

$$F = \frac{mv^2}{r}$$

$$75 = \frac{1(v)^2}{0.9}$$

$$v = 8.21 \text{ m/s}$$

$$a = \frac{v^2}{r}$$

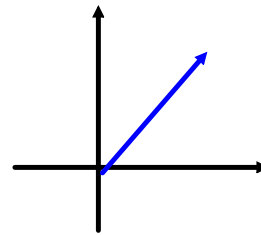
1. Two cars travel in the same direction along a straight highway, one at 60 km/hr and the other at 90 km/hr. (a) Assuming that they start at the same point, how much sooner does the faster car arrive at a destination 10 kilometers away? (b) How far must the faster car travel before it has a 15 minute lead on the slower car? (1, 2)

2. A particle undergoes a displacement of 5.0 m south, then 10.0 m east, and 15 m north. What is the direction and magnitude of the resultant displacement? (3)

$$d_T = -5\hat{j} + 10\hat{i} + 15\hat{j} = 10\hat{j} + 10\hat{i}$$

$$\text{mag} = \sqrt{10^2 + 10^2} = 10\sqrt{2} = 14.142\text{ m}$$

$$\text{dir} = \tan^{-1}\left(\frac{10}{10}\right) = 45^\circ \text{ N of E}$$



- 3 The minimum distance required to stop a car moving at 60 km/hr is 30 meters. What is the **minimum stopping distance** for the car moving at 90 km/hr, assuming the acceleration remains the same as before. (3)

$$v_i = 60 \div 3.6 = 16.67 \text{ m/s}$$

$$v_f = 0$$

$$a =$$

$$d = 30\text{ m}$$

$$t =$$

$$v_f^2 = v_i^2 + 2ad$$

$$0^2 = (16.67)^2 + 2a(30)$$

$$a = -4.63 \text{ m/s}^2$$

$$v_i = 90 \div 3.6 = 25$$

$$v_f = 0$$

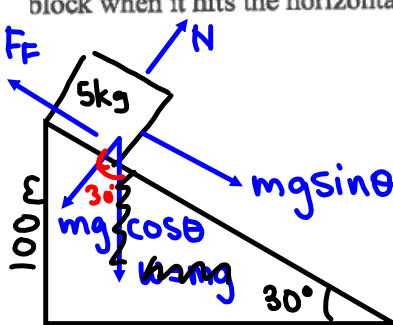
$$a = -4.63 \quad 0^2 = 25^2 + 2(-4.63)d$$

$$d = ?$$

$$d = \underline{67.5 \text{ m}}$$

$$t =$$

4. A 5 kg block rests 100 m high on a plane inclined at 30° to the horizontal. (a) Find the **force of friction** on the block. (b) If the coefficient of static friction is 0.2 what is the **maximum force of friction** before the block starts moving (c) If the plane were smooth, what would be the speed of the block when it hits the horizontal plane. (1,1,1)



$$a) \vec{F}_f = mg \sin \theta = 5(9.8) \sin 30 = 24.5 \text{ N}$$

up the incline.

$$b) N = mg \cos \theta = 5(9.8) \cos 30 = 42.43 \text{ N}$$

$$F_f = \mu N = 0.2(42.43) = 8.49 \text{ N up the incline}$$

$$v_i = 0$$

$$v_f = ?$$

$$a = 4.9$$

$$d = 200$$

$$t =$$

$$\sin 30 = \frac{100}{h}$$

$$h = 200\text{ m}$$

$$F = ma$$

$$mg \sin \theta = ma$$

$$9.8 \sin 30 = a$$

$$4.9 \text{ m/s}^2 = a$$

$$v_f^2 = v_i^2 + 2ad$$

$$v_f^2 = 0 + 2(4.9)(200)$$

$$v_f = 44.27 \text{ m/s}$$

5. If $\vec{A} = 2\hat{i} - \hat{j} + 4\hat{k}$ and $\vec{B} = -3\hat{i} - 2\hat{j}$, (a) find $\vec{A} + \vec{B}$, (b) find $\vec{A} \cdot \vec{B}$, (c) find $\vec{A} \times \vec{B}$

$$\vec{A} = \langle 2, -1, 4 \rangle \quad \vec{B} = \langle -3, -2, 0 \rangle$$

$$\vec{A} + \vec{B} = \langle 2, -1, 4 \rangle + \langle -3, -2, 0 \rangle = \langle -1, -3, 4 \rangle = -\hat{i} - 3\hat{j} + 4\hat{k}$$

$$\vec{A} \cdot \vec{B} = \langle 2, -1, 4 \rangle \cdot \langle -3, -2, 0 \rangle = (2)(-3) + (-1)(-2) + 4(0) = -4$$

$$\vec{A} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & -1 & 4 \\ -3 & -2 & 0 \end{vmatrix} = \hat{i} \begin{vmatrix} -1 & 4 \\ -2 & 0 \end{vmatrix} - \hat{j} \begin{vmatrix} 2 & 4 \\ -3 & 0 \end{vmatrix} + \hat{k} \begin{vmatrix} 2 & -1 \\ -3 & -2 \end{vmatrix}$$

$$\begin{vmatrix} a & b \\ c & d \end{vmatrix} = ad - bc = 8\hat{i} - 12\hat{j} - 7\hat{k}$$

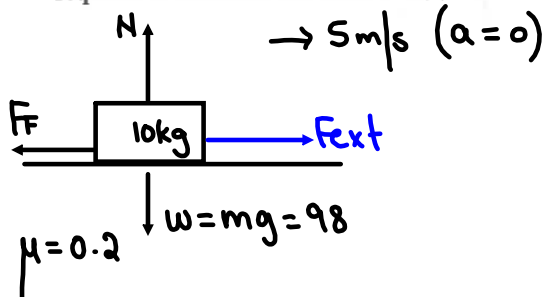
7. If a man weighs 90 kg on the earth ($g = 9.8 \text{ m/s}^2$). (a) What would be his weight on Jupiter, where the free fall acceleration is 25.9 m/s^2 ? (b) How much would be his mass on Jupiter? (c) What is his mass on the earth? (3)

$$a) W = mg = 90(25.9) = 2331 \text{ N (downwards)}$$

$$b) m_j = m_e = 90 \text{ kg}$$

$$c) m_e = 90 \text{ kg}$$

8. A body of mass 10 kg is moving with a constant velocity of 5 m/s on a horizontal surface. The coefficient of kinetic friction between body and surface is 0.2. (a) What is the horizontal force required to maintain the motion? (b) If the force is removed, how soon will the body come to rest? (3)



$$y: N = 98$$

$$F_f = \mu N = .2(98) = 19.6 \text{ N } (-\hat{i})$$

$$x: F_{ext} = F_f = 19.6 \text{ N } \hat{i}$$

$$v_i = 5 \quad F_f = ma$$

$$v_f = 0 \quad -19.6 = 10a$$

$$a = \leftarrow a = -1.96 \text{ m/s}^2 \hat{i}$$

$$d =$$

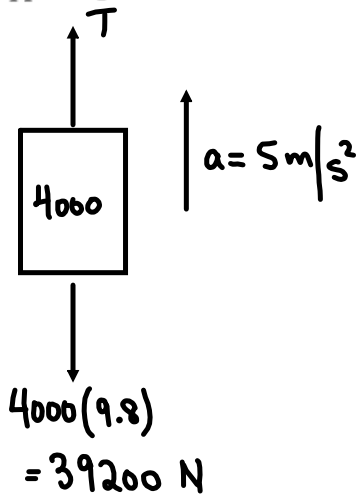
$$t = ?$$

$$v_f = v_i + at$$

$$0 = 5 + (-1.96)t$$

$$t = 2.55 \text{ s}$$

9. An elevator weighing 4000 kg rises with acceleration of 5 m/s^2 . (a) What is the tension in the supporting cable? (b) What is the tension in the cable if it comes down with a velocity of 15 m/s ?



$$F = ma$$

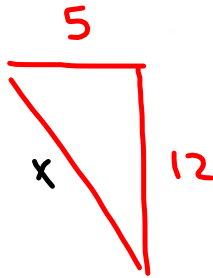
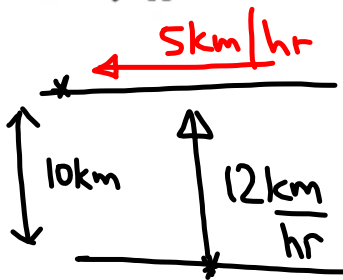
$$T - 39200 = 4000(5)$$

$$T = 59200 \text{ N up}$$

$$a = 0 \quad (3)$$

$$T = 39200 \text{ N up}$$

10. A boat pointing towards north crosses a 10 km wide river with a speed of 12 km/hr relative to water. The river has a uniform speed of 5 km/hr due west relative to earth. (a) Determine the speed of the boat relative to the stationary ground observer. (b) How much time will it take to reach the point directly opposite the starting point? (1,2)



$$x = \sqrt{12^2 + 5^2} = 13 \frac{\text{km}}{\text{hr}}$$

$$t = \frac{d}{v} = \frac{10 \text{ km}}{12 \text{ km/hr}} = 0.833 \text{ hrs}$$