

1. (5 points) If it took only a few cubic centimeters of paint to cover a scale model airplane that is a 1:12 model of the prototype, how much paint would be needed to cover the full size airplane? Assume the same kind of paint is used and applied with the same thickness of coating.

- a) 1/12 as much
- b) 12 times as much
- * \rightarrow c) 144 times as much
- d) 1728 times as much
- e) none of the above

area to be painted increases
as square of scale factor
 $12^2 = 144$

2. (5 points) A heavy crate is being pulled along a factory floor by tugging on a rope so that the crate moves with a steady speed. How many distinct objects interact with the crate so as to produce forces that significantly influence the motion of the crate?

- a) one object
- b) two objects
- * \rightarrow c) three objects
- d) four objects
- e) five objects

Earth - gravitational force
Rope - tensional force
Floor - normal & frictional components

3. (5 points) Which of Newton's three laws of motion has the effect of requiring that forces "come in pairs?"

- a) First Law
- b) Second Law
- * \rightarrow c) Third Law
- d) all of the above (a-c)
- e) none of the above (a-c), since forces do not "come in pairs"

forces are interactions
between pairs of objects

4. (5 points) For non-zero vectors **A** and **B**, the magnitude of the operation $\mathbf{A} \cdot (\mathbf{B} \times \mathbf{A})$ would be

- * \rightarrow a) zero
- b) AB
- c) A^2B
- d) AB^2
- e) none of the above, as this is an illegal operation

$\vec{B} \times \vec{A}$ is perpendicular to \vec{A}
 $\vec{A} \cdot (\text{something perpendicular}) = 0$

5. (5 points) Which of the following physical quantities are best represented by a vector

- a) work
- b) kinetic energy
- c) power
- d) all of the above (a-c)
- * \rightarrow e) none of the above (a-c)

} all are scalar quantities

6. (5 points) A box is placed on a rough floor (i.e., there is friction) and a rope is attached to it. The rope is pulled, horizontally, with gradually increasing force, until the box begins to slide. During the time the rope tension was increasing, but before the box actually began to move, the magnitude of the force exerted on the box by the floor

a) remained constant

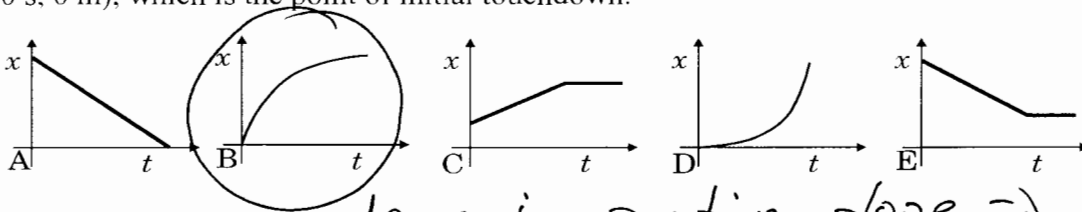
* b) increased

c) decreased

d) not enough information is provided

Normal component remains constant,
but frictional component (static)
increase toward $f_{s \text{ MAX}}$

7. (5 points) When landing, an airplane must reduce its speed from 170 mph, at touchdown on the runway, to rest, while traveling in a straight line along the runway. Utilizing thrust reversers, the plane can produce an acceleration (in the negative direction) of magnitude $g/4$. Take the positive direction as being "forward" for the plane. Which of the following **position vs time** graphs most appropriately represents the motion of the plane? The origin represents the point (0 s, 0 m), which is the point of initial touchdown.



decreasing positive slope \Rightarrow going forward but slowing

8. (5 points) A crate is being lowered down an inclined plane by applying a force horizontally to keep it from going too fast, as shown in the figure. Is the magnitude of the normal component of the force exerted by the incline on the crate greater than, less than, or equal to the weight of the crate?

a) less than the weight

b) greater than the weight

c) equal to the weight

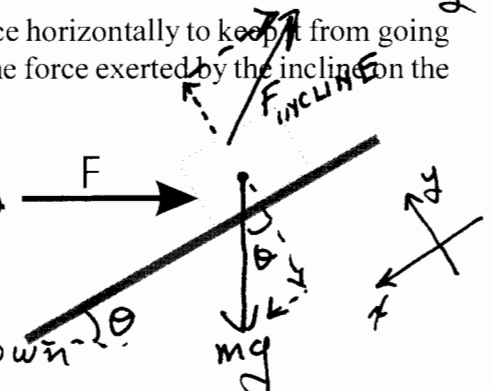
* d) yes

e) none of the above

from Σf_y

$$N = mg \cos \theta + F \sin \theta$$

unknown until angles and forces known



9. (5 points) The kinetic energy of an object is measured at two different, distinct moments in time. The energy values are identical. What can correctly be concluded about what occurred during the time elapsed between the two moments?

a) no forces acted on the object

b) forces may have acted, but no individual force did any work on the object

c) the object didn't move

* d) forces may have acted, but the net work done by all of them was zero

e) forces acted, but they were each perpendicular to the objects direction of motion

$$\Delta K = 0 = W_{\text{net}}$$

10. (5 points) A kilowatt-hour is a measure of

a) power

b) force

* c) energy

d) time

e) none of the above

$$\text{kW-hr} = (\text{kilo})(\text{watt})(\text{hour})$$

$$= (1000) \left(\frac{\text{Joule}}{\text{sec}} \right) (3600 \text{ s}) = 3,600,000$$

Joules
which is energy

11. (10 points) One cubic meter of aluminum has a mass of about 2700 kg. It can be rolled out into thin foil. If one cubic meter of aluminum were rolled into a sheet of foil 35 cm wide and 0.012 mm thick, how long would the sheet be?

- * → a) 2100 km
 b) 240 km
 c) 64 km
 d) 2.3 km
 e) none of the above are even approximately correct

$$V = l w t \Rightarrow l = \frac{V}{w t}$$

$$l = \frac{1 \text{ m}^3}{(0.35 \text{ m})(0.012 \times 10^{-3} \text{ m})} = 2.381 \times 10^5 \text{ m}$$

$$\approx 238 \text{ km} \approx 240 \text{ km to 2 sig. digits}$$

12. (10 points)

A dart is thrown horizontally with a speed of 18 m/s toward point P, located at the center of the bull's-eye of a dartboard. The dart strikes a point on the rim of the board directly below the bull's-eye 0.27 seconds after it was thrown. The dart missed the bull's-eye by how far?

- * → a) 48 cm
 b) 36 cm
 c) 13 cm
 d) 7.1 cm
 e) none of the above are even approximately correct

$$\vec{r}_f = \vec{r}_0 + \vec{v}_0 t + \frac{1}{2} \vec{a}_0 t^2$$

in y:

$$y_f = 0 \text{ m} + (0 \text{ m/s}) t_f + \frac{1}{2} (-g) (0.27 \text{ s})^2$$

$$= -0.3572 \text{ m}$$

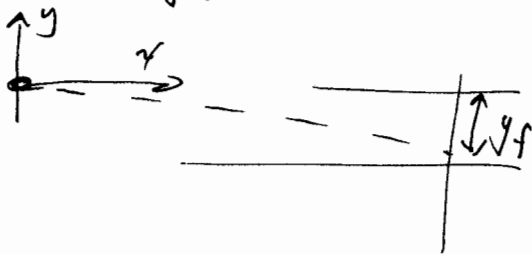
$$= \approx -36 \text{ cm}$$

$$t = 0 \text{ s} \quad t = t_f = 0.27 \text{ s}$$

$$\vec{r}_0 = 0 \hat{i} + 0 \hat{j} \text{ m} \quad \vec{r}_f = x_f \hat{i} + y_f \hat{j}$$

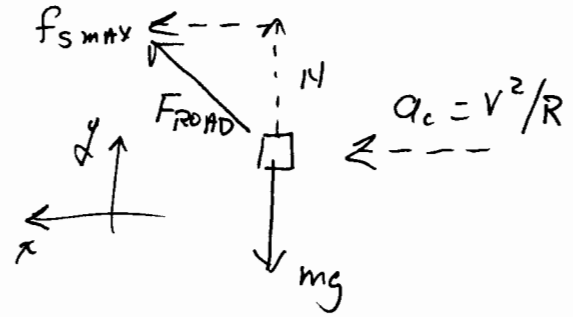
$$\vec{v}_0 = 18 \hat{i} + 0 \hat{j} \text{ m/s} \quad \vec{v}_f = ?$$

$$\vec{a}_0 = 0 \hat{i} - g \hat{j} \text{ m/s}^2 \quad \vec{a}_f = \vec{a}_0$$



13. (10 points) A bicyclist finds she skids when trying to round a particular curve of radius R . She goes to the bike shop and buys new and better tires which are advertized to have "twice the grip" as her old tires. With her physics background she interprets this to mean that the coefficient of static friction between her tires and the road will be twice as great as before. She should now be able, at the same speed as before, to negotiate without skidding a curve whose approximate radius is as small as

- a) 0.50 R
- b) 0.71 R
- c) 1.4 R
- d) 2.0 R
- e) none of the above are even approximately correct



$$\Sigma f_y = N - mg = mg \quad ?^0$$

$$N = mg$$

$$\Sigma f_x = f_{s \max} = \mu_s N = \mu_s mg = ma_x = ma_c = m v^2 / R$$

$$\mu_s m / g = m v^2 / R \quad R = \frac{v^2}{\mu_s g} \quad \text{if } \mu_{s2} = 2\mu_{s1} \text{ then } R_2 = \frac{1}{2} R_1$$

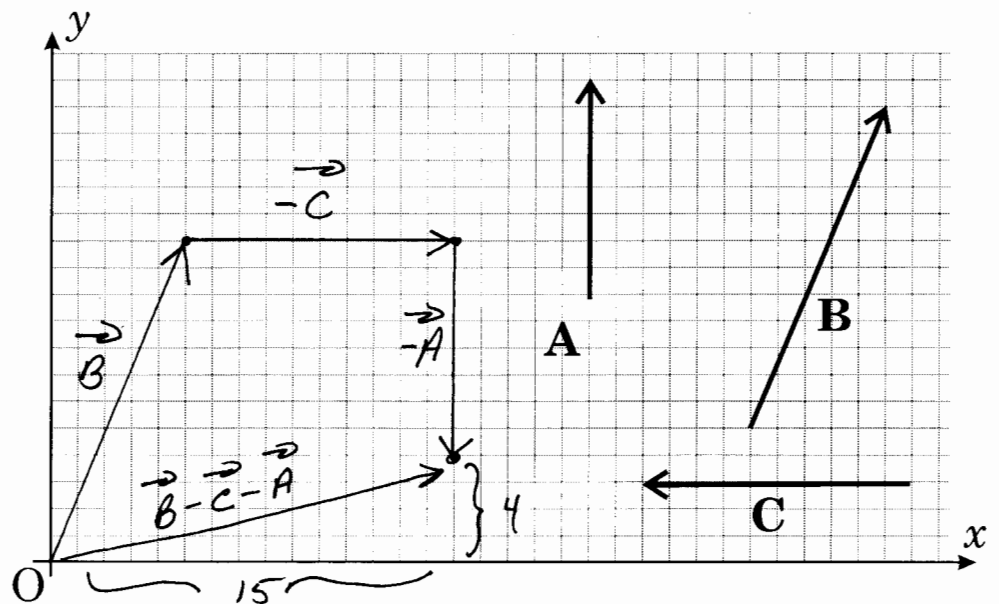
14. (10 points)

Three vectors, **A**, **B**, and **C** are drawn in the figure below. The magnitude of **C** is 20 km, and the other two vectors are drawn to the same scale as **C**.

What is the approximate magnitude of the vector operation, $\mathbf{B} - \mathbf{C} - \mathbf{A}$?

- a) 17 km
- b) 31 km
- c) 7.7 km
- d) 21 km
- e) none of the above are even approximately correct

$$\sqrt{15^2 + 4^2} = 15.52 \times (\text{scale factor of } 2 \text{ km/box}) = 31.04 \text{ km}$$



15. (10 points) Suppose you are driving your car at 55.0 mph (24.6 m/s) along a straight roadway when you suddenly notice an obstruction in the road. It takes 385 milliseconds for your brain and muscles to respond and get your foot from the gas pedal to the brake. You then brake as firmly as you can, decreasing your velocity at a constant rate of 3.20 m/s^2 until you come to rest. What total distance do you take to stop, beginning from the moment you first notice the obstruction.

- a) 94.7 m
- b) 237 m
- c) 189 m
- * \rightarrow d) 104 m
- e) none of the above are even approximately correct

distance while reacting

$$d_R = (24.6 \text{ m/s})(.385 \text{ s}) = 9.471 \text{ m}$$

distance while stopping

$$d_s = (24.6 \text{ m/s})(t_s) + \frac{1}{2}(-3.2 \text{ m/s}^2)(t_s)^2$$

$$v_f = 0 \text{ m/s} = 24.6 \text{ m/s} + (-3.2 \text{ m/s}^2)(t_s)$$

$$\text{so } t_s = 7.6875 \text{ s}$$

$$d_s = 94.55 \text{ m}$$

$$d_s + d_R = 104.03 \text{ m}$$

16. (10 points) A child ties a string 0.85 m long to a baseball (mass = 0.142 kg) and whirls it around his head in a horizontal circle so that it makes 72 revolutions per minute. The tension in the string will be approximately

- * \rightarrow a) 6.8 N
- b) 14 N
- c) 8.7 N
- d) 4.2 N

e) none of the above are even approximately correct

Hint: Yes, gravity is involved, but you may safely neglect its contribution without making more than a couple of percent change in the calculated answer.

$$v = \frac{\text{distance}}{\text{time}} = \frac{72(2\pi R)}{60 \text{ s}} = \frac{72(2\pi)(.85 \text{ m})}{60 \text{ s}}$$

$$= 6.409 \text{ m/s}$$

$$a_c = \frac{v^2}{R} = \frac{(6.409 \text{ m/s})^2}{.85 \text{ m}} = 48.32 \text{ m/s}^2$$

$$f_c = \text{tension} = m a_c = (.142 \text{ kg})(48.32 \text{ m/s}^2)$$

$$= 6.861 \text{ N}$$

17. (20 points) A freight elevator and its cargo have a combined mass of 3500kg. An electric motor connected to a cable hoist is to lift the loaded elevator to the top of a 45 story building that's under construction, a height of 150 m. The foreman on the job wants each lift to take no longer than 2.0 minutes.

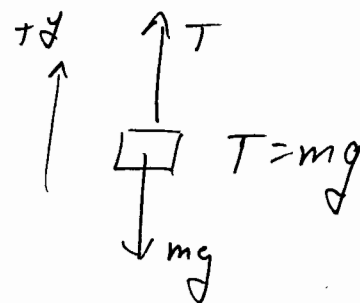
a) How much work must be done by the motor during each lift?

$$\begin{aligned}
 W &= \int \vec{f} \cdot d\vec{s} = \vec{f} \cdot \int d\vec{s} \\
 &= \vec{f} \cdot \vec{s} = f s \cos\theta \\
 &= (mg)(h) \cos 0^\circ = mgh
 \end{aligned}$$

$$= (3500 \text{ kg})(9.8 \text{ m/s}^2)(150 \text{ m})$$

$$= 5.145 \times 10^6 \text{ joules (positive)}$$

a scalar quantity



b) What should be the horsepower rating of the motor, if 1 hp = 746 watts.

$$P = \frac{W}{t} = \frac{5.145 \times 10^6 \text{ J}}{120 \text{ s}} = 4.29 \times 10^4 \text{ watts}$$

$$\div 746 \text{ w/hp} \Rightarrow 57.4 \text{ hp}$$

57.4 hp

18. (20 points) A constant force $\mathbf{F} = 230\mathbf{i} + 120\mathbf{j}$ newtons acts on a 50 kg mass as it moves in an x - y coordinate system from the point $(x,y) = (0,0)$ to the point P, where $(x,y) = (25, -10)$ meters.

a) How much work is done by the force on the mass? Be sure to indicate whether the work is positive or negative.

$$W = \int \vec{f} \cdot d\vec{s} = \vec{f} \cdot \int d\vec{s} \quad \text{since } \vec{f} \text{ is constant}$$

$$(230\hat{i} + 120\hat{j})_{\text{N}} \cdot (25\hat{i} - 10\hat{j})_{\text{m}} \quad \int d\vec{s} = \vec{r} = 25\hat{i} - 10\hat{j} \text{ m}$$

$$W = (230\text{N})(25\text{m}) + (120\text{N})(-10\text{m}) = \underline{455 \text{ J (positive)}}$$

a scalar quantity

there are no vector components or direction angles for work

b) If the mass had a velocity of 3.0 m/s in the positive x direction when it passed the origin, what will be its new speed (magnitude of velocity) when it reaches point P?

Use principles of work and energy to solve this problem. **DO NOT** employ a kinematic solution.

$$W = \Delta K = K_f - K_i = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 = \frac{1}{2} m (v_f^2 - v_i^2)$$

$$W = 455 \text{ J}$$

$$455 \text{ J} = \frac{1}{2} (50 \text{ kg}) [v_f^2 - (3 \text{ m/s})^2]$$

$$\underline{v_f = 5.2 \text{ m/s}}$$