Exercise. What force is needed to stop a 1000 kg car in 6 s if it is traveling at 90 km/h? (Assume constant acceleration) [redacted] (Pr 4.14)

$m = 1000\,kg,\ t = 6s\ ,\ v = 90\ km/h$

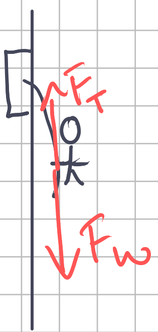
$$= \frac{90 \times 1000}{60 \times 60}\ m/s$$

$$= 25\,m/s$$

$F = ma,\ a = v/t = 25/6 \quad \therefore F = 1000\left(\frac{25}{6}\right) = 4166.\overline{6}$

$$= 4 \times 10^3\ N$$

Example. A 75 kg person wants to escape from a third story window. Unfortunately a make shift rope made of sheets tied together can support a mass of only 58 kg. How can the person safely use the rope?



$m_p = 75\,kg$

How much force can the rope handle before breaking?

$F_T = ma = 58(9.8) \approx 580\ N$

$F_w = 75(9.8) \approx -750\,N$

By second law: $\sum F = 0$

$F_T + F_w = F \iff 580 + -750 = ma$

$-170 = (75)a$

$\therefore a = \frac{-170}{75} = -2.26\ m/s^2$

$\boxed{\text{So, the person must descend at an acceleration no greater than } 2.26\,m/s^2}$

1. If a rectangle has sides of length 4.04 ± 0.03 m and 3.18 ± 0.04, what is the percentage uncertainty in its perimeter?

$P = 2L + 2W = 2(4.04) + 2(3.18)$
$= 8.08 + 6.36$
$= 14.44\ m$

$\Delta P = 2\Delta L + 2\Delta W = 2(0.03) + 2(0.04)$
$= 0.06 + 0.08$
$= 0.14$

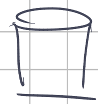
Thus, $P + \Delta P = 14.44 \pm 0.14$
$= 14.4 \pm 0.14\ m$

& $\frac{\Delta P}{P} \times 100 = \frac{0.14}{14.4} \times 100 = 0.97\%$

2. A solid cylinder has a diameter of 2.00 ± 0.02 cm, length 4.00 ± 0.02 cm and mass 106.81 ± 0.01 g. What is the density and uncertainty of the solid cylinder?

$r = 1 \pm 0.01$, $l = 4 \pm 0.02$, $m = 106.81 \pm 0.01$ g (all not in SI)

$(1 \pm 0.01) \times 10^{-2}$ $(4 \pm 0.02) \times 10^{-2}$ $(106.81 \pm 0.01) \times 10^{-3}$



$$\rho = \frac{\text{mass}}{\text{volume}} = \frac{m}{\pi r^2 l} = \frac{106.81 \times 10^{-3}}{\pi (1 \times 10^{-2})^2 (4 \times 10^{-2})} \frac{kg}{m^3} = 8500 \frac{kg}{m^3}$$

density

$$\Delta\rho = \left(\frac{\Delta m}{m}\right) + 2\left(\frac{\Delta r}{r}\right) + \left(\frac{\Delta l}{l}\right) = \frac{0.01}{1} + 2\left(\frac{0.02}{4}\right) + \left(\frac{0.01}{106.81}\right)$$

$$= 0.01 + 0.01 + 9.36 \times 10^{-5}$$

$$= 0.02$$

Thus $\rho \pm \Delta\rho = 8500 \pm 0.02$ kg/m³

3. A jumbo jet travels 2100 km at a speed of 1000 km/h. Then, to conserve fuel, it slows down to 500 km/h for the next 2100 km. What is the average speed, in km/h, of the jet?

ONLY VALID FOR CONSTANT ACCEL.

$\bar{v} = \frac{v_i + v_2}{2}$, $\frac{x_1 + x_2}{t}$

1000 km/h → 500 km/h →

2100 km 2100 km

t in first interval: $\frac{2100}{1000} = 2.1$ hr, t in second interval: $\frac{2100}{500} = 4.2$ hr

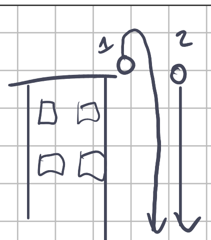
$$\frac{2100 + 2100}{2.1 + 4.2} = \frac{4200}{6.3} = 666.\bar{6} = 667 \text{ km/h}$$

12. Two objects are thrown from the top of a tall building. One is thrown up, and the other is thrown down, both with the same initial speed. What are their speeds just before they hit the ground?

A) The one thrown up is traveling faster.
B) The one thrown down is traveling faster.
C) They are traveling at the same speed.
D) It is impossible to tell because the height of the building is not given.

(Terminal velocity)

$F_d = F_g$



$v_f^2 = v_i^2 + 2a(x_f - x_i)$, $v_{i1} = v_{i2} = v_i$

$x_{i1} = x_{i2} = x_i$

$v_{f1}^2 = v_i^2 + 2a(0 - x_i)$ $x_{f1} = x_{f2} = 0$

$v_{f1} = v_i^2 - 2ax_i$

We notice that this eqn only depend on the initial velocity & disp., which is the same for objects 1 & 2.

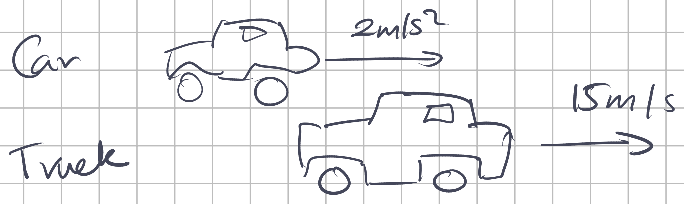
13. A jet fighter plane is launched from a catapult on an aircraft carrier. It reaches a speed of 42 m/s at the end of the catapult, and this requires 2.0 s. Assuming the acceleration is constant, what is the length of the catapult?
a) 16 m
b) 24 m
c) 42 m
d) 84 m

As this speed is not instantaneous, we need to find the average accel.

$$\bar{v} = \frac{v_i + v_f}{2} = \frac{0 + 42}{2} = 21 \text{ m/s}$$

$$x = vt = 21 \text{ m/s } (2s) = \underline{42 m}$$

14. At the instant a traffic light turns green, a car that has been waiting at the intersection starts ahead with a constant acceleration of 2.00 m/s^2. At that moment a truck traveling with a constant velocity of 15.0 m/s overtakes and passes the car.
(a) Calculate the time necessary for the car to reach the truck.
(b) Calculate the distance beyond the traffic light that the car will pass the truck.
(c) Determine the speed of the car when it passes the truck.



a) We find displacement eq^{n}s for both cars & then set them equal & solve for t.

$$x_{fc} = \cancel{x_{ic}}^{0} + \cancel{v_{ic}}^{0} t + \tfrac{1}{2} a_c t^2$$

$$x_{ft} = \cancel{x_{it}}^{0} + v_{it} t + \tfrac{1}{2} \cancel{a_t}^{0} t^2$$

Then, $x_{fc} = x_{ft} \Leftrightarrow \tfrac{1}{2} a_c t^2 = v_{it} t$

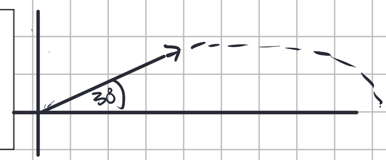
$$\Rightarrow t = \frac{2 v_{it}}{a_c} = \frac{2(15)}{2} = 15 \text{ seconds}$$

b) $x_{fc} = \tfrac{1}{2} a_c t^2 = \tfrac{1}{2}(2)(15)^2 = 15^2 = 225\,m$

c) $v_c = v_i + at = 0 + 2(15) = 30\,m/s$

17. A soccer ball is kicked with a velocity is 25.0 ms^{-1} at an angle of 30° above the horizontal ground.
(a) How long will it take the ball to return to the ground?

(b) How far does the ball travel horizontally before striking the ground?



a) $v_i = 25\,m/s, \quad \theta = 30°$

$v_y = 25 \sin\theta - gt$ Set this equal to zero to find the point where the ball starts to descend.

$$0 = 25\sin(30) - 9.8t \Rightarrow t = \frac{25\sin(30)}{9.8} = 1.28\,s$$

So, for the ball to return to the ground: $2(1.28) = 2.6\,s$
(because 1.28s is when ball is at the peak).

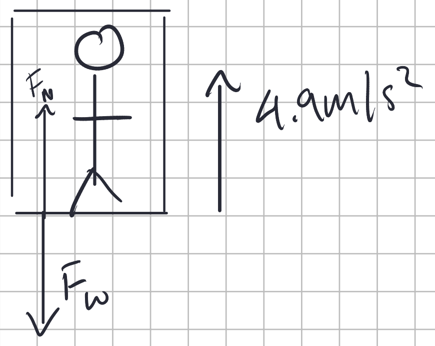
b) $x_x = v_{ix} t = 25\cos(30)(t) = 25\cos(30)(2.56) = 56\,m$

21. A hammer (mass 0.5 kg) and a stone (1 kg) are dropped from a height of 2 m. Which of the following statement is correct? Assume no air resistance.
a. The stone easily reaches the ground first.
b. The hammer easily reaches the ground first.
c. both reach the ground at the same time.
d. It is not possible tell which will reach the ground first.

$m_h = 0.5\,kg, \quad m_s = 1\,kg \quad x = 2$

as mass is only related to force only, this has no influence on our answer, thus, we have the conclusion found in Q12

25. A person on a scale rides in an elevator. If the mass of the person is 60.0 kg and the elevator accelerates upward with an acceleration of 4.90 m/s^2, what is the reading on the scale?
A) 147 N
B) 294 N
C) 588N
D) 882N



$F_W = -60(9.8)$

$F_N = 60(9.8)$

$F_{Elevator} = 60(4.9)$

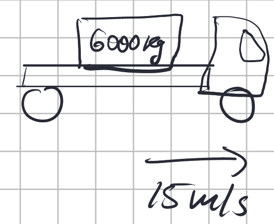
$F_{N\ elevator} = -60(4.9)$

So the force on the scale is $60(9.8) + 60(4.9)$
$= 882N$

From this you can find the apparent weight: $882 = m(9.8)$
$\approx 88kg$

So, on this elevator, the person feels about 22kg heavier as it ascends.

26. An object of mass 6000 kg rests on the flatbed of a truck. It is held in place by metal brackets that can exert a maximum horizontal force of 9000 N. When the truck is traveling 15 m/s, what is the minimum stopping distance if the load is not to slide forward into the cab?
A) 15 m
B) 30 m
C) 75 m
D) 150m



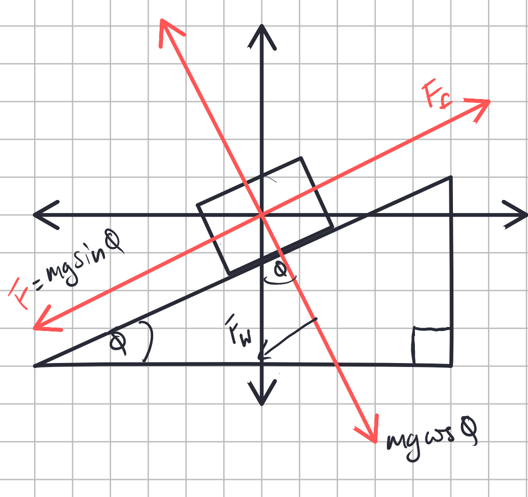
$F = ma \Leftrightarrow 9000 = 6000a \Rightarrow a = 3/2\ m/s^2$

So, if the truck decellerates faster than $1.5 m/s^2$, the block will collide with the truck.

$v_f^2 = v_i^2 + 2a(x_f - x_i)$

$0^2 = 15^2 + 2(1.5)(x_f - 0) \Leftrightarrow \frac{-15^2}{3} = x_f = -75m$

Thus, you need at least 75m of stopping distance. This most likely means that 6000kg is either unrealistic to drive, or the supports are not



IGNORE!!

29. What is the correct unit of work expressed in SI units?

A) kg m/s2
B) kg m2/s
C) kg m2/s2
D) kg2 m/s2

$W = Fs$, F units of $kg \cdot m/s^2$, s units of m

So, W units of $kg \cdot m^2/s^2$

30. If you walk 5.0 m horizontally forward at a constant velocity carrying a 10-~~N~~ kg object, the amount of work you do is

A) more than 50 J
B) equal to 50 J
C) less than 50 J, but more than 0 J
D) zero.

answer

A force can be exerted on an object and yet do no work. If you hold a heavy bag of groceries in your hands at rest, you do no work on it. You do exert a force on the bag, but the displacement of the bag is zero, so the work done by you on the bag is $W = 0$. You need both a force and a displacement to do work. You also do no work on the bag of groceries if you carry it as you walk horizontally across the floor at constant velocity, as shown in Fig. 6–2. No horizontal force is required to move the bag at a constant velocity. The person shown in Fig. 6–2 exerts an upward force $\vec{F}_P$ on the bag equal to its weight. But this upward force is perpendicular to the horizontal displacement of the bag and thus is doing no work. This conclusion comes from our definition of work, Eq. 6–1: $W = 0$,

31. A child's swing is pulled back to a height of 1.28 m above the lowest position. If the swing is released and mechanical energy is conserved then it will reach a maximum speed of

A) 5 ms^{-1}
B) 9.8 ms^{-1}
C) 19.6 ms^{-1}
D) 25 ms^{-1}
E) none of these

Conservation of energy: $\frac{1}{2}mv^2 + mgh = 0$

$$\frac{1}{2}mv^2 = -mgh$$

$$\cancel{m}(\tfrac{1}{2}v^2) = \cancel{m}(-gh)$$

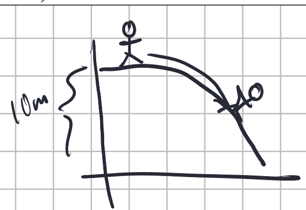
$$v^2 = -2gh, \quad g = -9.8$$

$$v = \sqrt{(-2)(-9.8)h}, \quad h = 1.28$$

$$= 5 m/s$$

33. A skier, of mass 40 kg, pushes off the top of a hill with an initial speed of 4.0 m/s. Neglecting friction, how fast will she be moving after dropping 10 m in elevation?

A) 7.3 m/s
B) 15 m/s
C) 49 m/s
D) 196 m/s



$m = 40kg$, $F_g = mg \approx -400N$

$W = Fs = -400(10) = -4000$ J

$E = \frac{1}{2}mv^2$

$4000 = \frac{1}{2}mv^2$

$\frac{2(4000)}{m} = v^2$

$v = \sqrt{\frac{2(4000)}{40}} = 14.14$