

Dynamics Warmup

(Stuff You Should Remember)

Note: To simplify calculations, you may use $g = 10 \text{ m/s}^2$ in all problems

Section A – True/False

Indicate if each statement is true or false.

1. T A force can be defined as a push or pull on an object.
2. T Gravity is the only force acting on an object in free fall.
3. F All forces acting on an object must be in the same direction.
4. T Friction always opposes the motion of an object.
5. F An object at rest has no forces acting on it.
6. T When analyzing forces, both magnitude and direction are important.
7. T The normal force acts perpendicular to the contact surface.
8. T When two objects collide, they exert forces on each other equally.
9. T Gravity is the only force acting on an object in free fall.
10. T The formula for calculating weight is $W = mg$, where m is the mass and g is the acceleration due to gravity.

Section B – Multiple Choice

Each of the questions or incomplete statements below is followed by four suggested answers or completions. Select the one that is best in each case and then circle the corresponding letter.

11. Suppose an object is accelerated by a force of 100 N. Suddenly a second force of 100 N in the opposite direction is exerted on the object, so that the forces cancel. The object

(A) is brought to rest rapidly.
(B) decelerates gradually to rest.
(C) continues to move at the velocity it had before the second force was applied.
(D) is brought to rest and then accelerates in the direction of the second force.

12. A 5 kg object is pushed with a force of 20 N. What is its acceleration?

(A) 5 m/s²
(B) 4 m/s²
(C) 10 m/s²
(D) 2 m/s²

$$F = ma$$
$$a = \frac{F}{m} = \frac{20}{5}$$

13. An object of mass 3 kg is accelerating at 2 m/s². What is the force acting on it?

(A) 9 N
(B) 3 N
(C) 6 N
(D) 12 N

$$F = ma$$
$$= 3(2)$$

14. What is the weight of a 12 kg mass on Earth?

(A) 100 N
(B) 117.6 N
(C) 150 N
(D) 120 N

$$W = mg$$
$$= 12(10)$$

15. An object is pushed with a force of 60 N. If it has a mass of 15 kg and experiences a frictional force of 15 N, what is the acceleration?

- (A) 5 m/s²
 (B) 2 m/s²
 (C) 3 m/s²
 (D) 4 m/s²



$$\Sigma F = ma$$

$$\frac{F_A - F_f}{m} = a$$

$$\frac{60 - 15}{15} = a$$

16. A 30 kg object is lifted vertically with a constant velocity. What is the force required to lift it?

- (A) 300 N
 (B) 250 N
 (C) 294 N
 (D) 200 N



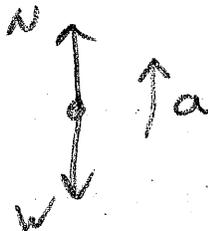
$$\Sigma F = ma$$

$$F_A - W = 0$$

$$F_A = mg = 30(10)$$

17. A woman stands on a bathroom scale in a motionless elevator. When the elevator begins to move, the scale briefly reads 75% of her weight. The acceleration of the elevator is

- (A) 2.5 m/s² up
 (B) 2.5 m/s² down
 (C) 0.25 m/s² up
 (D) 0.25 m/s² down



$$\Sigma F = ma$$

$$N = 0.75W$$

$$N - W = ma$$

$$0.75W - W = ma$$

$$0.75mg - mg = ma$$

$$(0.75 - 1)g = a$$

$$a = -2.5$$

18. A 30 kg box is pushed across a rough, flat, horizontal surface at a constant velocity with a force of 150 N. The coefficient of friction between the box and the surface is

- (A) 0.2
 (B) 0.5
 (C) 2
 (D) 5



$$\Sigma F = ma$$

$$F_A - F_f = 0$$

$$F_f = F_A$$

$$\Sigma F = ma$$

$$N - W = ma$$

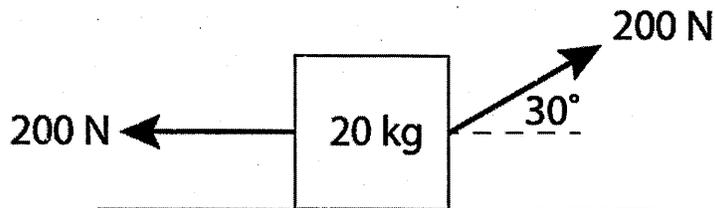
$$N = W$$

$$= mg$$

$$F_f = \mu F_N$$

$$\mu = \frac{F_f}{F_N} = \frac{F_A}{mg} = \frac{150}{30(10)}$$

19. A 20 kg box sits on a flat frictionless surface. Two forces of 200 N are applied to the box as shown in the diagram.

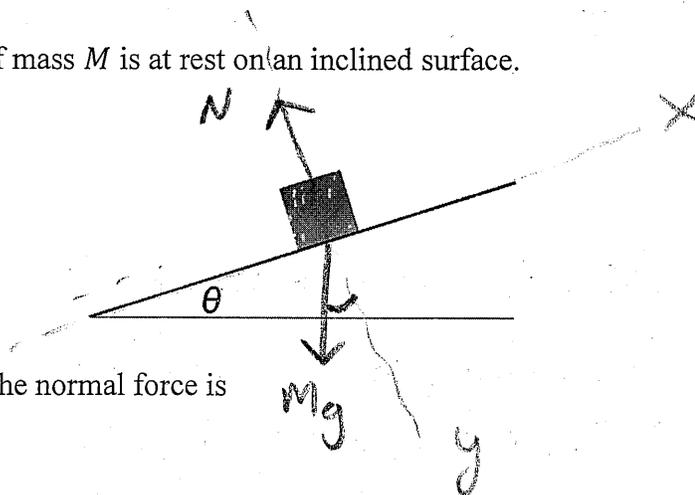


Which statement best describes the motion of the box?

- (A) The box is lifted off the surface.
(B) The box accelerates to the right.
(C) The box does not move.
(D) The box accelerates to the left.

*Force right > force left
Applied force up < weight.*

20. A concrete block of mass M is at rest on an inclined surface.



The magnitude of the normal force is

- (A) Mg
(B) $Mg \sin \theta$
(C) $Mg \cos \theta$
(D) $Mg \tan \theta$

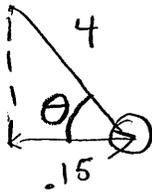
Section C – Free Response

Answer the questions in the space provided.

21. A 27 kg chandelier hangs from a ceiling on a vertical 4.0-m long wire.

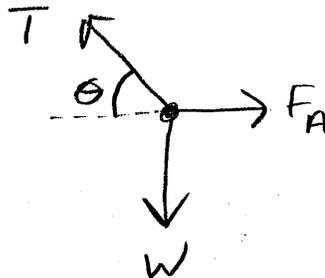
- (a) What horizontal force would be necessary to displace its position 0.15 m to one side?
- (b) What will be the tension in the wire?

(a)



$$\cos \theta = \frac{.15}{4}$$

$$\theta = 88^\circ$$



$$\Sigma F = ma \quad a=0$$

$$F_A - T \cos \theta = 0$$

$$F_A = T \cos \theta$$

$$\Sigma F = ma \quad a=0$$

$$T \sin \theta - W = 0$$

$$T \sin \theta = W$$

$$T = \frac{W}{\sin \theta}$$

$$F_A = mg \frac{\cos \theta}{\sin \theta}$$

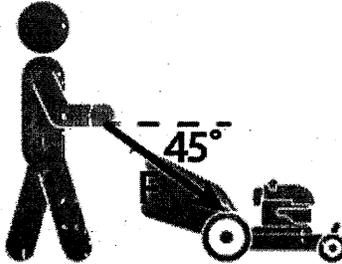
$$= 27(10) \frac{\cos 88}{\sin 88}$$

$$F_A = 9.4 \text{ N}$$

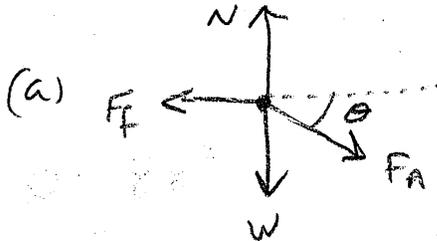
$$(b) \quad T = \frac{W}{\sin \theta} = \frac{mg}{\sin \theta} = \frac{27(10)}{\sin 88}$$

$$T = 270 \text{ N}$$

22. A person pushes a 14.0 kg lawn mower at constant speed with a force of 88.0 N directed along the handle, which is at an angle of 45.0° to the horizontal.



- (a) Draw a free-body diagram showing all forces acting on the mower.
 (b) Calculate the horizontal friction force acting on the lawn mower.
 (c) Calculate the normal force acting on the lawnmower.
 (d) What force must the person exert on the lawn mower to accelerate it from rest to 1.5 m/s in 2.5 seconds, assuming the same frictional force?



(b)

$$\sum F = ma \quad a = 0$$

$$-F_f + F_A \cos \theta = 0$$

$$F_f = F_A \cos \theta$$

$$= 88 \cos 45$$

$$F_f = 62 \text{ N}$$

(d) $v_0 = 0$

$$v = 1.5$$

$$a = ?$$

$$t = 2.5$$

$$v = v_0 + at$$

$$a = \frac{v}{t} = \frac{1.5}{2.5} = 0.6 \text{ m/s}^2$$

(c)

$$\sum F = ma \quad a = 0$$

$$N - W - F_A \sin \theta = 0$$

$$N = W + F_A \sin \theta$$

$$= 14(10) + 88 \sin 45$$

$$N = 202 \text{ N}$$

$$\sum F = ma$$

$$-F_f + F_A \cos \theta = ma$$

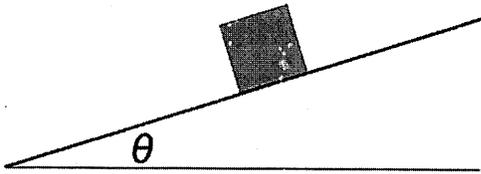
$$F_A = \frac{ma + F_f}{\cos \theta}$$

$$= \frac{14(0.6) + 62}{\cos 45}$$

$$\cos 45$$

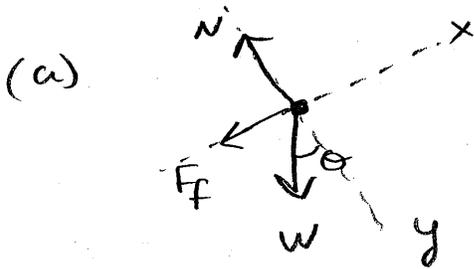
$$F_A = 100 \text{ N}$$

23. A crate has an initial speed of 3.0 m/s up the 25.0° plane as shown.



The coefficient of kinetic friction between the box and the plane is 0.12.

- (a) How far up the plane will it go?
 (b) How much time elapses before it returns to its starting point?



$$\begin{aligned} \frac{x}{\Sigma F = ma} \\ -F_f - mg \sin \theta = ma \\ -\mu FN - mg \sin \theta = ma \\ -\mu mg \cos \theta - mg \sin \theta = ma \end{aligned}$$

$$\begin{aligned} \frac{y}{\Sigma F = ma} = 0 \\ N - mg \cos \theta = 0 \\ N = mg \cos \theta \end{aligned}$$

$$\begin{aligned} a &= -0.12(10) \cos 25 - 10 \sin 25 \\ a &= -5.314 \text{ m/s}^2 \end{aligned}$$

$$v_0 = 3$$

$$v = 0$$

$$a = -5.314$$

$$x = ?$$

$$\begin{aligned} v_f^2 &= v_0^2 + 2ax \\ x &= \frac{v_f^2 - v_0^2}{2a} = \frac{-(3)^2}{2(-5.314)} \end{aligned}$$

$$x = 0.85 \text{ m}$$

(b) time up

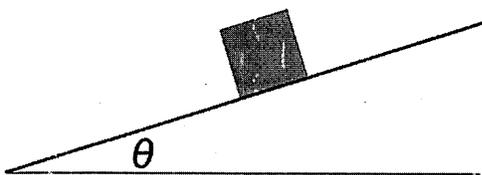
$$v = v_0 + at$$

$$t = \frac{v - v_0}{a} = \frac{0 - 3}{-5.314} = 0.56$$

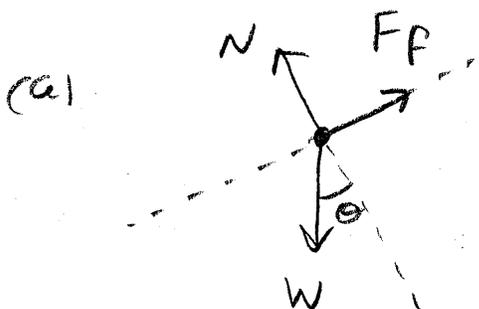
time up = time down
 so total time is 0.56×2

$$t = 1.125$$

24. A box sits at rest on a rough 33° inclined plane.



- (a) Draw the free-body diagram, showing all the forces acting on the box.
 (b) Calculate the coefficient of static friction between the box and the plane.



(b) $\frac{x}{\Sigma F = ma} \quad a=0$

$$-mg \sin \theta + f_f = 0$$

$$f_f = mg \sin \theta$$

$\frac{y}{\Sigma F = ma} \quad a=0$

$$N - mg \cos \theta = 0$$

$$N = mg \cos \theta$$

$$f_f = \mu f_N$$

$$\mu = \frac{f_f}{f_N}$$

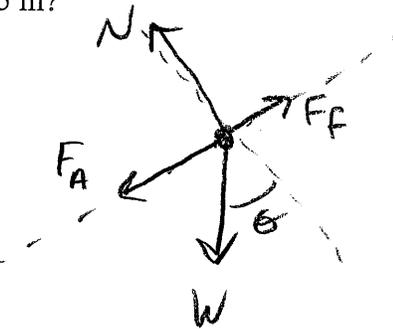
$$= \frac{mg \sin \theta}{mg \cos \theta}$$

$$\mu = \tan \theta$$

$$= \tan 33$$

$$\boxed{\mu = 0.65}$$

25. The coefficient of kinetic friction for a 22 kg bobsled on a track is 0.10. What force is required to push it, from rest, down a 6.0° incline and achieve a speed of 60 km/h at the end of 75 m?



$$60 \text{ km/h} = 17 \text{ m/s}$$

$$v_0 = 0$$

$$v = 17$$

$$x = 75$$

$$a = ?$$

$$v^2 = v_0^2 + 2ax$$

$$a = \frac{v^2}{2x} = \frac{(17)^2}{2(75)} = 1.927 \text{ m/s}^2$$

$$\frac{x}{\Sigma F = ma}$$

$$F_A + W \sin \theta - F_f = ma$$

$$F_A = ma - mg \sin \theta + \mu F_N$$

$$F_A = ma - mg \sin \theta + \mu mg \cos \theta$$

$$= m(a - g \sin \theta + \mu g \cos \theta)$$

$$= 22(1.927 - 10 \sin 6 + 0.1(10) \cos 6)$$

$$= 19.5$$

$$\boxed{F_A = 20. \text{ N.}}$$

$$\frac{y}{\Sigma F = ma} \quad a = 0$$

$$N - W \cos \theta = 0$$

$$N = mg \cos \theta$$