Unit Review: Dynamics

1. All forces can be grouped into just four kinds of forces. Name the force that best describes the following:

   a) the weakest force.

   b) the force that acts over the longest distance.

   c) the strongest force.

   d) the force that holds matter together.

2. A physics book is motionless on the top of a table. If you give it a hard push with your hand, it slides across the table and slowly comes to a stop. Use Newton's first law of motion to answer the following questions.

   a) Why does the book remain motionless before the force is applied?

   b) Why does the book move when the hand pushes on it?

   c) Why does the book eventually come to a stop?

   d) Under what conditions would the book remain in motion at a constant speed?

3. Suppose you dropped a rock from a bridge into a valley below. Earth pulls on the rock and accelerates it downward. According to Newton's third law, the rock must also be pulling on Earth, yet we don't notice the Earth accelerating upward. Explain.

4. Let's say your textbooks have a total mass of 3.0 *kg*. What would be the mass of the books if they were taken to Jupiter where the acceleration due to gravity is 10 times that of Earth?

5. Suppose the acceleration of an object is zero. Does this mean there are no forces acting on it? Give an example supporting your answer.

In the following questions, assume that friction is negligible, unless stated otherwise.

6. A towrope is used to pull a 1750 *kg* car, giving it an acceleration of $1.35\ m/s^2$. What force does the rope exert? ($2.36\times10^3\ N$ in the direction of the acceleration)

7. A racing car undergoes a uniform acceleration of $4.00\ m/s^2$. If the net force causing the acceleration is $3.00\times10^3\ N$, what is the mass of the car? (750 *kg*)

8. A 5.2 *kg* bowling ball is accelerated from rest to a velocity of 12 *m/s* as the bowler covers 5.0 *m* of approach before releasing the ball. What force is exerted on the ball during this time? (+74.88 *N*)

9. An 873 *kg* dragster, starting from rest, attains a speed of 26.3 *m/s* in 0.59 *s*.

   a) Find the average acceleration of the dragster during this time interval. ($+44.6\ m/s^2$)

   b) What is the size of the average force on the dragster during this time interval? ($+3.89\times10^4\ N$)

   c) Assume the driver has a mass of 68 *kg*. What horizontal force does the seat exert on the driver? ($+3.03\times10^3\ N$)

10. The dragster in problem 9 completed the 402.3 *m* run in 4.936 *s*. If the car had constant acceleration, what would be its acceleration and final velocity? ($+33.02\ m/s^2$, +163 *m/s*)

11. When a karate strike hits wooden blocks, the hand undergoes an acceleration of $-6500\ m/s^2$. Medical data indicates the mass of the forearm and hand to be about 0.7 *kg*. What is the force exerted on the hand by the blocks? What is its direction? ($-4.55\times10^3\ N$, opposite to the direction of the hand's motion)

12. After a day of testing race cars, you decide to take your own 1550 *kg* car onto the test track. While moving down the track at 10 *m/s*, you suddenly accelerate to 30 *m/s* in 10 *s*. What is the average net force that you have applied to the car during the 10 *s* interval? ($+3.1\times10^3\ N$)

13. A race car has a mass of 710 *kg*. It starts from rest and travels 40 *m* in 3.0 *s*. The car is uniformly accelerated during the entire time. What net force is applied to it? ($+6.31\times10^3\ N$)

14. A force of –9000 *N* is used to stop a 1500 *kg* car traveling at 20 *m/s*. What braking distance is needed to bring the car to a halt? ($33.\overline{3}\ m$)

15. When a 20 *kg* child steps off a 3.0 *kg* stationary skateboard with an acceleration of $0.50\ m/s^2$, with what acceleration will the skateboard travel in the opposite direction? ($3.\overline{3}\ m/s^2$)

16. A 70 *kg* hockey player coasts along the ice on steel skates. If the coefficient of kinetic friction is 0.010

   a) what is the force of friction? (–6.9 *N*)

   b) How long will it take him to coast to a stop, if he is traveling at 1.0 *m/s*? (10 *s*)

17. A 10 kg box is pulled across level floor, where the coefficient of kinetic friction is 0.35. What horizontal force is required for an acceleration of $2.0\ m/s^2$? (54 *N*)

18. A small 10 *kg* cardboard box is thrown across a level floor. It slides a distance of 6.0 *m*, stopping in 2.2 *s*. Determine the coefficient of friction between the box and the floor. (0.26)

19. A boy pulls a 50 *kg* crate across a level floor with a force of 200 *N*. If the force acts at an angle of $30°$ up from the horizontal, and the coefficient of kinetic friction is 0.30, determine

    a) the normal force exerted on the crate by the floor. (390 *N* [up])

    b) the horizontal frictional force exerted on the crate by the floor. (–120 *N*)

    c) the acceleration of the crate. ($+1.1\ m/s^2$)

20. A can of pop is given a shove. It slides across a table, eventually coming to a stop. If its initial velocity is 2.0 *m/s*, and the coefficient of kinetic friction between the two surfaces is 0.20, how far will it travel across the table? (1.0 *m*)

21. You pull your 18 *kg* suitcase at constant speed on a horizontal floor by exerting a 43 *N* force on the handle, which makes an angle θ with the horizontal. The force of friction on the suitcase is 27 *N*.

    a) What angle does the handle make with the horizontal? ($51°$)

    b) What is the normal force on the suitcase? (140 *N* [up])

    c) What is the coefficient of friction? (0.19)

22. A skier skiing downhill reaches the bottom of a hollow with a velocity of 20 *m/s*, and then coasts up a hill with a $10°$ slope. If the coefficient of kinetic friction is 0.10, how far up the slope will she travel before she stops? (75 *m*)

23. A 62 *kg* person on skis is going down a hill sloped at $37°$. The coefficient of kinetic friction between the skis and the snow is 0.15. How fast is the skier going 5.0 *s* after starting from rest? (+24 *m/s*)

24. You push a 325 *N* trunk up a $20°$ inclined plane at a constant velocity by exerting a 211 *N* force parallel to the plane's surface.

    a) What is the component of the trunk's weight parallel to the plane? (111 *N*)

    b) What is the sum of all forces parallel to the plane's surface? (0)

    c) What are the magnitude and direction of the frictional force? (100 *N* [dts])

    d) What is the coefficient of friction? (0.327)

25. A 2.5 kg block slides down a $10°$ inclined plane with constant acceleration. The block starts from rest at the top. At the bottom, its velocity is 0.65 m/s. The incline is 1.6 m long.

    a) What is the acceleration of the block? ($0.13\ m/s^2$ [dts])

    b) What is the coefficient of friction? (0.45)

    c) Does the result of either a or b depend on the mass of the block?

In the following problems, assume that $\vec{g} = 9.8\ m/s^2$ unless stated otherwise.

26. A 95.0 *kg* boxer has his first match in the Canal Zone ($\vec{g} = 9.782\ m/s^2$) and his second match at the North Pole ($\vec{g} = 9.832\ m/s^2$).

    a) What is his mass in the Canal Zone? (95.0 *kg*)

    b) What is his weight in the Canal Zone? (929.29 *N*)

    c) What is his mass at the North Pole? (95.0 *kg*)

    d) What is his weight at the North Pole? (934.04 *N*)

27. Your new motorcycle weighs 2450 *N*. What is its mass in kilograms? (250 *kg*)

28. You place a 7.50 *kg* television set on a spring scale. If the scale reads 78.4 *N*, what is the acceleration of gravity at that location? ($10.45\ m/s^2$)

29. On Planet X, a 50 *kg* barbell can be lifted by only exerting a force of 180 *N*.

    a) What is the acceleration of gravity on Planet X? ($3.6\ m/s^2$)

    b) If the same barbell is lifted on Earth, what minimal force is needed? ($4.9\times10^2\ N$)

30. A proton has a mass of $1.672\times10^{-27}\ kg$. What is its weight? ($1.64\times10^{-26}\ N$)